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Physiology, Hygiene and First Aid

(Prepared in accordance with the New S. S. L. C. Syllabus)

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PREFACE

This little book is written to cover the new Syllabus in Physiology, Hygiene and First Aid, prescribed for the S. S. L. C. Course in the Madras Presidency. Details which are difficult for young minds have been omitted and great care has been taken to present the main facts of Physiology in as intelligible a way as possible. It is hoped that the pupils for whom the book is intended will find it useful.

Sincere thanks are due to my colleague, Mr. John E. Chelladorai, M.A., for the help he rendered in writing certain portions of the book.

May 1930. K. S. PADMANABHA AIYER.

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Physiology, Hygiene and First Aid

CHAPTER I

THE GENERAL BUILD OF THE HUMAN BODY

I hope that with the help of the little book on animal life you have learnt something about the common animals around you. Let us now turn our attention to ourselves and try to know something about the build of our own body and its working. The human body is a very wonderful machine. It is dangerous for you, boys and girls, to grow up without acquiring at least some elementary knowledge about your body, the organs contained in it, and the functions performed by them. Most of the ailments that people suffer from are due to a lack of this knowledge. Just as a machinist should know the parts of his machine and its working, so that he may keep it in good order, so is a knowledge of the structure and working of our body essential to us in order that we may keep it in perfect condition. You must remember that it is your duty to keep strong and fit, so that you may carry out satisfactorily your every-day duties, and be useful citizens of the motherland.

Before wę study each part of the body in detail, let us first take a broad survey of the whole body. The body consists of a head, trunk and limbs. The trunk is connected with the head by means of the neck. The limbs are two pairs (an upper and a lower) and are attached to the trunk.

Inside the body is a frame-work of bone. This bony supporting frame-work is called the *Skeleton*. The skeleton is covered with flesh (muscles) and the flesh by skin.

The head bears the organs of sense (the eyes, the ears, and the organs of smell and taste) by means of which we derive our knowledge of the outside world. In addition, the head carries the brain enclosed in a strong bony box. The brain is the most important part of the body, for, it is the seat of intelligence, and it controls the work of every part of the human machine.

The trunk is hollow and has a spacious cavity inside. The cavity of the trunk is divided into an upper chamber, called the cavity of the chest or *Thorax*, and a lower chamber, called the cavity of the *Abdomen*, by a sheet-like horizontal partition of muscles called the *diaphragm*.

The wall of the *Thorax* consists of a few pairs of curved rod-like bones called the *ribs*, which start from the *spine* at the back and, sweeping forwards, meet a flat plate-like bone in front termed the *breast bone*. In the cavity of the thorax are the two *lungs* (right and left) with the fleshy *heart* between them. The lungs are the organs of breathing, and the *heart* is the organ which pumps blood to the various parts of the body.

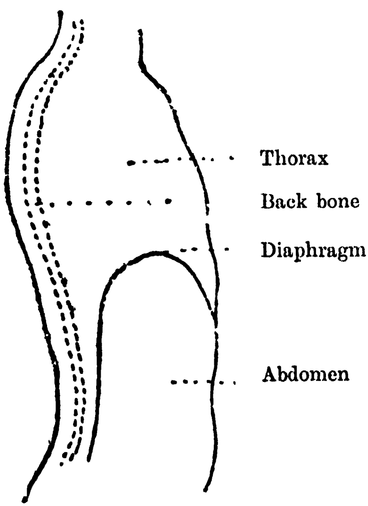


Fig. 1. Thorax and Abdomen.

The cavity of the abdomen is bounded by the sheet-like diaphragm above and the hip bones below. In this cavity are placed the *stomach, intestines, liver, pancreas spleen* and *kidneys*. The gullet which passes down the chest pierces the diaphragm and enters the abdomen It then widens into a spacious bag

called the stomach, on the left side of the abdomen. The stomach narrows into a long tube (intestines) which lies in several coils. The end of this long tube opens to the outside in the middle of the lower end of the abdomen by the anus. The entire tube beginning from the mouth and ending at the anus is called the *food tube* or *alimentary canal,* since it is concerned with the alimentation or nutrition of the body. On the right side of the upper part of the abdomen is the large, dark brown organ called the *liver*. Situated behind the stomach is a long flat structure known as the *pancreas*. Both the liver and the pancreas are 'glands'. They prepare certain juices necessary for digesting the food and pour them into the food tube. Lying behind the coiled intestines, attached to the body wall of the back, are two bean-shaped organs called the *Kidneys*. In front of the end of the food canal there lies a thin-walled sac called the *bladder*. The kidneys and the bladder are concerned with the removal of urine from the body.

We have now seen from our general survey of the body that it consists of many parts (organs) *e.g.*, the brain, the organs of sense, the lungs, the heart, the food canal, the liver, the pancreas, the kidneys, etc., each organ having assigned to it a particular function and all working together harmoniously for the good of the whole body.

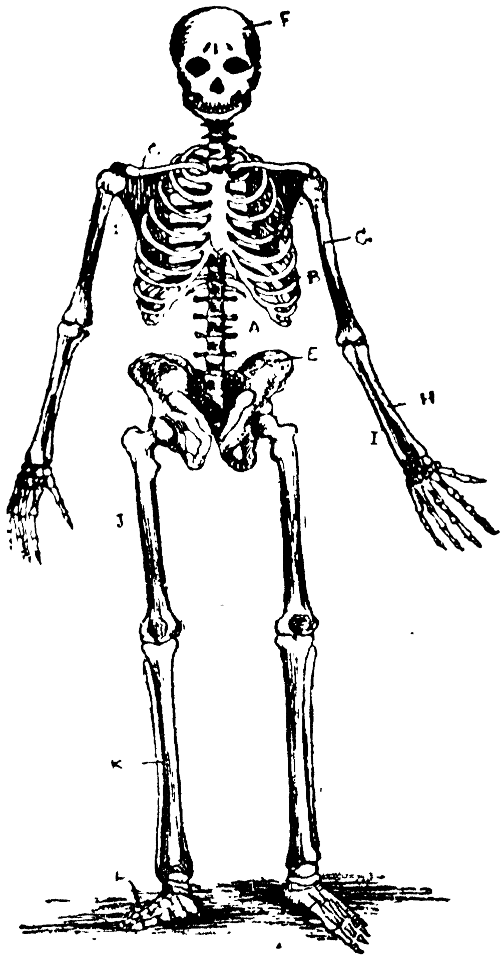


Fig. 2. The Human Skeleton—A. Vertebral column; B. Ribs; C. Clavicle; D. Shoulder blade; E. Hip bone; F. Skull; G. Humerus; H. Radius; I. Ulna; J. Femur; K. Calf bones; L. Bones of the Foot.

CHAPTER II

THE SKELETON

How graceful is the human body! What beautiful proportions! It is the internal frame-work of bone that gives to the body the dignified bearing and the fine proportions. How ugly we would look without this supporting frame-work and what awkward movements we would be making if we did not possess a skeleton!

The skeleton of our body may be divided into (1) the skull (2) the back bone (3) the skeleton of the chest and (4) the skeleton of the limbs and limb girdles.

The Skull.—The Skeleton of the head is the *Skull.* The skull is not a single bone but is composed of a number of bones fitted tightly together. It consists of two parts, namely, a bony box for the brain, called the *Cranium,* and the bones of the face. The brain case or cranium is smooth and rounded and is itself made up of several flat bones with thin edges firmly dovetailed into each other. (The edges of these bones are saw-like with a series of tooth-like projections. The projections of one bone firmly interlock with those of the adjacent bones). You may know that the brain is the most important organ in the body and an injury to it may cause insanity

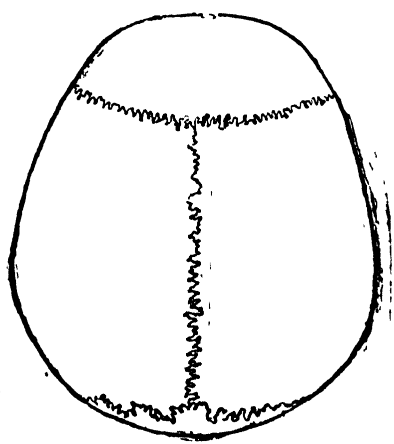


Fig. 3. Top of Skull showing Suture between the bones.

or death. That is why it is placed within such a strong bony case. In little infants the bones of the Cranium do not fit together for, if they do the brain cannot grow in size. The bones of the face have a pair of cup-like sockets for the eyeballs and a pair of cavities in which the organs of smell are placed. Of the two jaws, the upper jaw is firmly fixed to the bones of the face, while the lower jaw is freely movable and is attached to the skull below the ear. The external flap of the ear is not really the hearing part. The real organ of hearing is placed deep in each side of the skull.

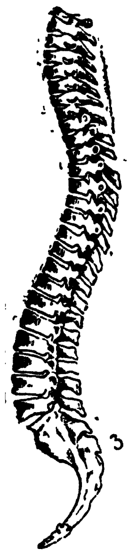


Fig. 4. Vertebral column.

The back bone or vertebral column.—If you run your finger down the middle of your back you feel a hard rod-like something. This is the back bone or *vertebral column,* as it is more correctly called, for it is not one *single* bone but a column of thirty-three bones placed one over the other. The column forms a strong support for the head and trunk.

Let us examine a single bone (vertebra) from the column. It consists of a thick solid 'body' bearing a bony ring. The ring has three projections on it, one directed backwards, and the two others towards the sides. The bony rings of the vertebrae together form a continuous canal or tube down which runs the *spinal cord.* The spinal cord is a tail-like downward continuation of the brain. Like the brain the spinal cord also is very

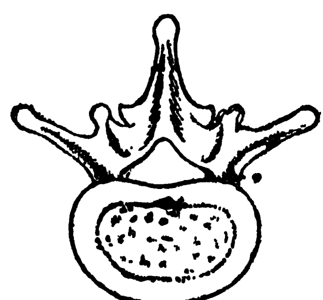


Fig. 5. A Vertebra.

important and needs special protection from injury. That is why it is placed in a strong bony tube. The bodies of the vertebrae give strength to the column and the bony processes on the rings serve for the attachment of muscles and ligaments which bind the vertebrae together. Thick cushion-like pads of a sort of elastic tissue are placed between the bodies of the vertebrae. These pads, besides making the column greatly flexible, act as buffers preventing any shock from being carried to the brain.

The first and second vertebrae are different from the rest. The first supports the skull and is known as the *Atlas.*

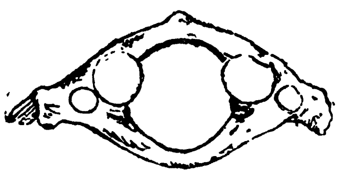


Fig. 6. **The Atlas.**

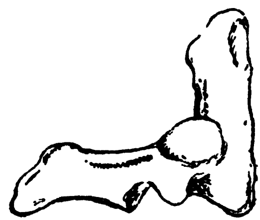


Fig. 7. **The Axis.**

It is ring-shaped and has no body. On the upper side of the ring are two shallow depressions on which the skull rests. When we nod, the skull moves backwards and forwards on the Atlas. The second, called the *Axis*, bears a peg-like process. When the head is moved from side to side, the atlas with the skull on it moves round this peg which serves as a pivot.

Towards the lower end of the column, five vertebrae are fused together to form a single bony piece, the *Sacrum.* The sacrum forms a kind of keystone for the hip girdle, the two halves of which are firmly attached to it, one on each side. At the lower end of the sacrum are four small vertebrae, also fused together and resembling

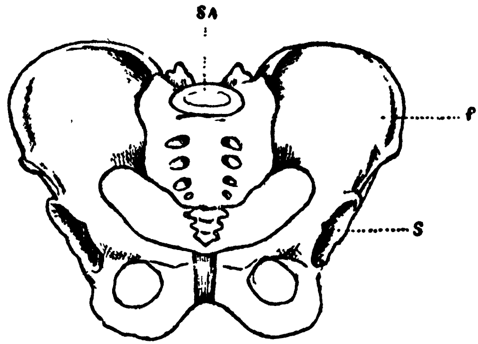


Fig. 8. **The Sacrum and Hip bones.**—S. A. Sacrum ; P. Ilium ;S. Acetabulum

a tail. In fact it is a rudimentary tail. In mammals which possess a tail, this part of the vertebral column is long and consists of many more bones.

The framework of the chest.—The skeleton of the chest forms a sort of bony cage. It is made up of the upper half of the spinal column at the back, the flat breast bone in front and twelve pairs of ribs at the sides. The breast bone is a flat bone about six inches in length. The ribs are curved, flat, and rod-like. Each pair of ribs start from the sides of a vertebra to which they are movably attached, sweep round the chest with a little down-ward slope and are

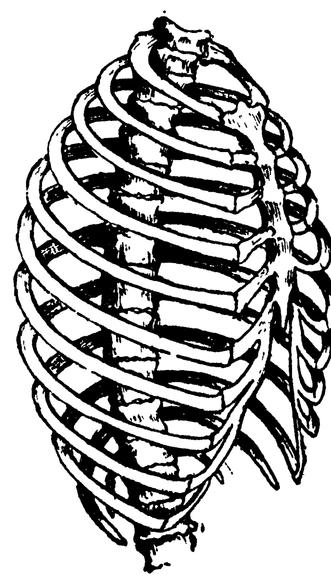


Fig. 9. **The Skeleton of the Chest.**

attached to the breast bone in front, by strips of cartilage. The two bottom pairs of ribs do not reach the front of the chest and are not, therefore, attached to the breast bone. They are, therefore, called "floating ribs."

The ribs can be slightly raised from their natural slanting position by means of certain muscles by which they are joined together. When the ribs are thus raised, the size of the chest cavity is increased. By reason of this fact, the ribs play an important part in respiration. Further, the bony cage-like frame work of the chest serves to protect the two important organs contained in it, namely, the heart and the lungs.

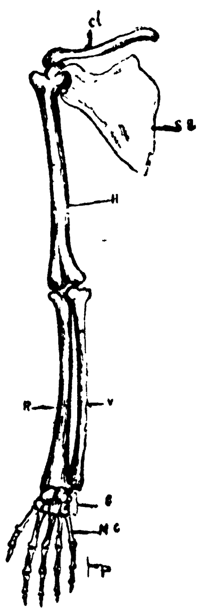


Fig. 10. Bones of the arm with Shoulder blade and Clavicle. Cl. Clavicle; S. B. Shoulder blade; H. Humerus; R. Radius; Ulna; C. Bones of the wrist; M. C. and P. Bones of the hand.

Skeleton of the limbs and limb girdles.—Each arm consists of four parts—the upper arm, the forearm, the wrist and the hand. In the upper arm there is only one long bone, the *humerus*. In the fore arm there are two long bones lying parallel to each other, namely, *the radius* and *the ulna,* the radius being on the thumb side. The wrist is composed of eight small bones. The palm of the hand has five long bones starting from the wrist and each of the fingers has three bones while the thumb has but two.

The upper end of the humerus is rounded like a ball. This rounded end fits into a shallow cup borne by a broad, flat, triangular bone at the back of the chest called the *shoulder blade.* (Feel with your right hand the left shoulder blade)

There is, on each side, a rod-like bone called the *collar bone,* the inner end of which is attached to the top of the breast bone and the outer end to the shoulder blade near its junction with the humerus. The collar bones serve to keep the arms well apart, so that their movements may have a wide range. The two shoulder blades and collar bones together form a sort of girdle (incomplete behind), known as the *shoulder girdle.* The skeleton of the arms is suspended from this girdle.

Like the arm, each leg is divisible into four parts, namely, the thigh, the calf, the ankle and the foot. The thigh has a single long bone called the *femur* with a rounded head. The calf has like the forearm two long bones, one of which, called the splint bone, is very slender. The knee joint between the thigh and the calf is protected by a small bone, the knee cap. The ankle consists of seven irregular bones, one of which forms the heel. The foot, like the palm of the hand, has five long bones, and each toe has the same number of bones in it as the corresponding finger.

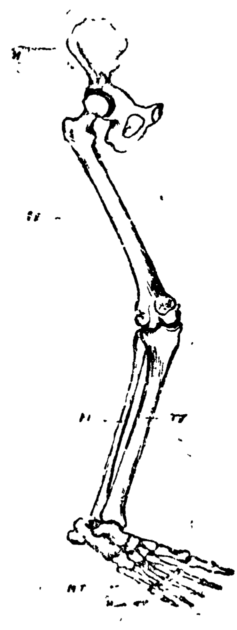


Fig. 11. Bones of the Leg. H. Hip bone; F. Femur; Fi. and Ti. Calf bones; M. T. and P. Bones of the foot.

The legs are attached to the hip girdle which is composed of two hip bones with the sacrum wedged in between them at the back. The edges of the hip bones can be felt at the sides of your hips. Each hip bone has on its outer side a deep circular cup into which the rounded head of the thigh bone fits. The two hip bones with the sacrum between them form a kind of shallow basin called the *pelvis.*

Joint.—A joint is formed by the meeting of two bones. There are many joints in our skeleton and they are of various types. We have already seen how the bones of the cranium (brain case) are joined together. Since no movement is possible between the bones of the brain case, these joints are termed *immovable joints.* Now look at the shoulder, elbow, wrist, hip, knee and ankle joints. All these allow movements and are, therefore, termed *movable joints.* The shoulder joint is formed by the shoulder blade and the humerus. The upper end of the humerus is rounded and ball-like. This ball fits into a cup-like socket in the shoulder blade. This type of movable joint in which the rounded end of one bone fits into a cup-like socket of the other is called *a ball and socket joint.* This kind of joint allows a wide range of motion. You may move your arm in any direction. To lessen friction between the ends of the two bones, the ball of the humerus and the cup of the shoulder blade are lined by smooth gristle. Further, the joint is kept well lubricated (oiled) with a slimy fluid. In order that the ball may not slip out of the socket, the whole joint is enclosed by tough bands of a fibrous, slightly elastic material called ligament.

The hip joint is also a ball and socket joint but the cup is deeper and the joint, therefore, does not allow as much freedom of movement as the shoulder joint. The elbow joint is of another type. In this case, only a backward and forward movement is possible. Such a joint is termed a *hinge joint.* The ankle, the wrist, and the joints between the bones of the fingers are all hinge joints.

Uses of the Skeleton.—The skeleton is of very great use to the body. It is the supporting frame work of the body giving it grace and proportions. Of the 206 bones which make up the entire skeleton, some are of use for the protection of important organs like the brain, spinal cord, heart, etc.. some are meant for support and others are of use in bringing about movements. Movements are brought

about by the contraction of muscles and the bones serve for the attachment of these muscles. The movements of the various parts of the leg and the arm are brought about by the contraction of muscles attached to the bones of these parts. When the biceps contracts, it moves (raises) the fore arm to which its end is attached.

What bone is made of.—Bone is composed of mineral matter and animal matter. The mineral matter is mostly lime and it is this that makes the bone hard and brittle. If a piece of bone (for instance, a rib) be heated in a fire for a sufficiently long time it gets very brittle and easily crumbles to pieces. This is because all the animal matter in it has been burnt away and only the hard mineral matter remains. On the other hand, if a similar bone be kept in a weak solution of acid, such as nitric or hydrochloric acid, the mineral matter will be dissolved out and the animal matter only will remain. The bone will become so soft and flexible that it could be bent or twisted or even tied into a knot. The bones of young children have more animal matter in them than the bones of grown-up people. Consequently in children the bones do not usually *break* during accidents but only bend like a green stick producing what is commonly known as a 'green-stick fracture.' As the children grow, the animal matter in the bones gradually decreases and the mineral matter increases. *Bone cells*—Bone is a living tissue like muscle or blood. Just as the muscles are made up of living muscle cells, so bone is also made up of living bone cells. These living bone cells have the curious property of producing chalky material round them. All the solid stuff that we find in a bone is the product of the living bone cells within it.

CHAPTER III

THE MUSCULAR SYSTEM

The muscles in the body form a third of its weight. Forming such a large part of the body, the muscles must have many important functions to perform. All bodily movements whether in walking, in running or in playing tennis etc., are brought about by them. The food that we take is made to travel through the food tube as a result of muscular action. The breathing movements are brought about by the action of the chest muscles. The blood is kept constantly circulating through the body by the muscles of the heart, and when they cease to function, life itself becomes extinct. No wonder it is that the muscles form such an important part of the body.

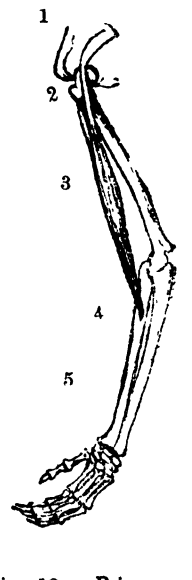


Fig. 12. **Biceps and bones of the arm.** 1. Shoulder blade; 2. Upper tendons of biceps; 3. Body of biceps; 4. Lower tendon of biceps; 5. Radius.

Just as all the bones in the body together form the bony or the skeletal system, so do all the muscles together form them muscular system.

A typical muscle.—When you bend your elbow, you will not fail to notice a lump developing on the front side of your upper arm. This lump is the muscle called *biceps*. If you happen to follow a system of physical exercise, it is at this muscle that you fondly gaze from time to time to gauge the progress of your muscular development.

The biceps consists of three parts. In its middle is a swollen, red, fleshy part called the body of the muscle and at its

either ends are narrow, white, rope-like structures called tendons. At the upper end of the body of the biceps are two tendons which are attached to the shoulder blade and at its lower end is a single tendon attached to the *radius*, one of the bones of the fore-arm.

The work of the muscle.—The special work of the muscle is to contract. When a muscle contracts, it shortens in length but at the same time it increases in girth. It is because of this increase in thickness that the biceps shows out as a lump when the arm is bent. Of the parts of a muscle, it is the body alone that is capable of contraction, and the contracting body pulls upon the tendons at its two ends. The tendons are incapable of contraction and their work is merely to conduct the pull to the bones to which they are attached. When the biceps contracts, it exerts a pull through its tendons upon the shoulder blade above and the radius below. Of these two bones, the shoulder blade is fixed and the radius free. As a consequence, when the biceps contracts, the radius is drawn up

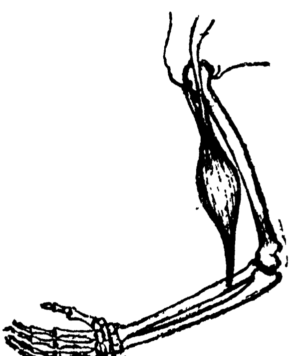


Fig. 13. The biceps muscle contracted.

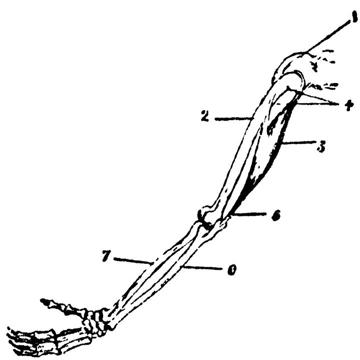


Fig. 14. The triceps muscle. 1. Scapula; 2. Humerus; 3. Body of Triceps; 4. Upper tendons; 5. Lower tendon; 6. Ulma; 7. Radius.

and the arm becomes bent at the elbow. Thus, it is by the contraction of the biceps that the arm is bent. How is the arm then straightened? On the back side of the upper arm is another muscle called *triceps* and when it contracts, the arm is straightened. The work of the triceps is therefore exactly opposed to that of the biceps. Clearly then, if both these muscles contract at the same time there will be a vain tug of war between them which will prevent both flexion and extension of the arm. What really takes place, however, is that while one muscle contracts, the other remains passive. The biceps and triceps contract alternately.

Kinds of muscles.—It is, when we *wish* to bend our arm that the biceps contracts and it is when we *wish* to straighten the arm that the triceps contracts. They act in accordance with our wishes. They are therefore under

Fig. 15. Tendons on the back of the hand.

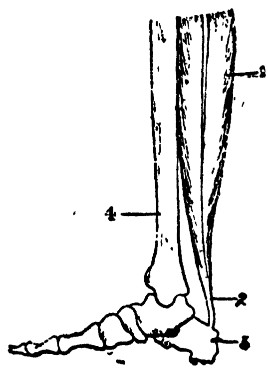


Fig. 16. Tendon of calf muscle at the back of the foot.

1. Body of calf muscle;
2. Tendon of calf muscle;
3. Heel bone; 4. Tibia.

the control of our will. Such muscles as are under the control of our will are said to be voluntary muscles.

(Voluntary derived from the Latin word *Voluntas* meaning will). All the muscles of the body are, however, not under the control of our will. The muscles of the food tube, of the urinary bladder, of the heart &c., are instances of muscles which are not under the control of our will. Our wish can neither make these muscles contract, nor can it stop them from contraction when they are undergoing contractions. The beating of the heart, for instance, cannot be stopped by our wish.

Moreover, the involuntary muscles are not usually attached to bones (*e.g.*) the muscles of the food tube, of the heart and of the bladder are unconnected with bones. The voluntary muscles like the biceps and the triceps are, however attached to bones. The latter are therefore also called skeletal muscles.

Movements.—The biceps and the triceps by their action bend or straighten the arm. Similar voluntary, skeletal muscles bring about the various bodily movements. While the flexion or the extension of the arm is due to the contraction of a single muscle, a very large number of muscles is concerned in effecting the movements in walking, running, riding a cycle &c.

Posture.—Not only do the skeletal muscles bring about the various bodily movements, but they also enable us to maintain the body erect while sitting or standing. When sitting erect on a stool or bench, the muscles on the front side of the trunk are in a state of moderate contraction and thereby prevent the trunk from falling backwards. So also the muscles on the back side of the trunk remain in a state ot moderate contraction and prevent the body from sinking forwards. It is by the balanced action of the trunk muscles in front and behind that the erect sitting posture is maintained. When standing erect, besides the muscles of the trunk, the leg muscles also take part. The trunk muscles keep the trunk erect and the leg muscles prevent the leg from sagging at the knee.

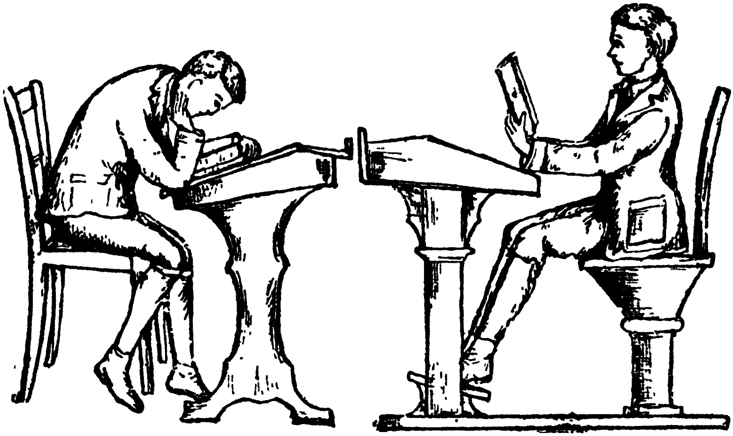


Fig. 17. **Wrong sitting posture.** Fig. 18. **Correct sitting posture.**

Correct and faulty postures.—When you sit on a chair or bench you may sit erect or more often you may sit with a forward stoop. Which of these postures is better, to sit erect or to sit with a stoop? To decide the question, make a simple experiment on your own body. Place your hand with fingers outspread half against the front of the chest and half against the abdomen. Now sit erect and breathe deeply a few times. Do you notice that the chest and the abdomen freely rise and fall? Now sit with a forward stoop, and breathe as before. Do you notice that the rise and fall of the chest and of the abdomen is very much less? What is this difference due to? In the latter case, owing to the forward stoop the lower part of the chest is unable to expand freely. As a result, the lower part of the lungs cannot, during breathing, take in or give out the full quantity of air that they are capable of. These parts of the lungs therefore do not derive the full benefits of breathing. As regards the abdomen, you notice that even as you stoop forward, it becomes compressed. The contained abdominal

organs are therefore pressed together: and their blood vessels are partially compressed. The blood cannot freely flow through these organs. As long as the compression lasts, *i e.* as long as you sit with a forward stoop, the abdominal organs must suffer from a reduced blood supply.

On the other hand when you sit erect there is no such drawback. The chest is free to expand fully and the lungs can have the full benefits of breathing; the abdominal organs are not compressed and they may have their due blood supply. Clearly then sitting erect is a healthy posture and sitting with a stoop is an unhealthy one. Any unhealthy posture is a malposture and in sitting, any deviation from the erect posture is unhealthy. To sit with a bend to one side while engaged in writing is another example of malposture.

Malpostures may not cause any serious discomfort if assumed once in a while, but are likely to lead to trouble if persisted in and developed into a regular habit. Then it may lead to the weakening of the lungs and of the abdominal organs, the circulation of which is interfered with. and thereby, to loss of health. It may even lead to the bending of the spine which shows out as a physical deformity.

As an example of such an extreme case we may refer to the goldsmiths Many of these workers in gold, you will have noticed sit stooping over a small fire or a little anvil, hours on end day after day. Many of them walk with a slight stoop with a curved back and a hollow chest.

To sit squarely on the bench or chair with the weight o the body evenly distributed on the pelvis and to hold the trunk and head erectly poised is the correct sitting posture. You must have seen sometime or other the image of the meditating Buddha. What a faultless pose!

To maintain the correct sitting posture, benches with suitable back rests are necessary.

Faulty postures may also be readily assumed while standing. The evil effects are the same as those for sitting

in incorrect postures. To stand erect with the weight of the body evenly resting on both the feet is the correct standing posture.

Structure of a muscle.—If a small bit of the leg muscle of a frog is suitably prepared and examined under the microscope it is seen that it is made up of a large number of long thread-like structures. Each of these is a muscle-fibre. Each muscle-fibre is a narrow elongated cell. The cell shows numerous close-set transverse stripes. Owing to the presence of these stripes, the muscle-fibre is said to be a striped or striated muscle-fibre. In a muscle these fibres are best bound together in small bundles by means of connective tissue. Then all the small bundles of a muscle are enclosed in a sheath of connective tissue. The muscle-fibres are found only in the body of the muscle, the tendon being made up of connective tissue.

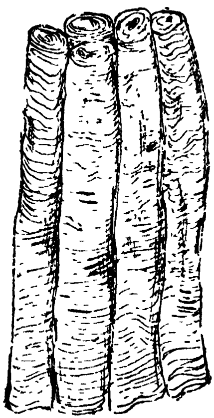


Fig 19 **Striated muscle-fibre.**

Muscle and Blood supply.—Running to each muscle is a large blood vessel called an artery. This conveys blood to the muscle. In the muscle it divides repeatedly into smaller and smaller branches. These small branches finally lead into extremely narrow blood vessels called capillaries. These run between the various muscle fibres. They then lead into out-going blood vessels called veins which carry off the blood from the muscle. Thus, through arteries the blood flows to muscles and through veins the blood flows away from them.

Muscle and its nerve.—A large muscle runs to each muscle. The nerve divides into many branches. Each branch divides finally into fine fibres called nerve-fibres. A

nerve-fibre is seen to run to each muscle-fibre. The function of the nerve is seen to run to each muscle-fibre. The function of the nerve is to connect the brain and the muscle. Messages from the brain are sent to the muscle through the nerve. Normally a muscle contracts only on receiving a message from the brain. Should the nerve happen to be cut accidentally, no messages from the brain can reach the muscle and it remains without contracting.

Muscle and heat production.—We have already mentioned that when a muscle contracts, it shortens in length and increases in girth. This is a change in form and it is not the only change in a contracting muscle. A resting muscle always contains in it a store of food materials. These food materials are found to be carbo-hydrates (vide chapter on food). When the muscle contracts, the carbo-hydrates combine with the oxygen derived from the blood. As a result of this oxidation, a definite quantity of heat is liberated. A contracting muscle thus liberates heat. The muscles in the body form a third of its weight and the heat produced in them contributes largely to the body-heat to keep it warm. You must have felt how after violent physical exercise your body glows with heat. The body temperature however, does not rise as the profuse sweating that follows, removes the excess of heat. On a very cold day, when the air temperature is low, the body tends to lose considerable amounts of heat. But then we shiver. Shivering is but muscular contraction and the heat so liberated compensates for the great loss of heat.

General effects of Physical Exercise.—In a contracting muscle, oxidation of the carbohydrates takes place, the necessary oxygen being obtained from the blood stream. Vigorously contracting muscles use up considerable quantities of oxygen. To meet their increased demand for oxygen, the action of the heart is quickened and the blood is pumped more quickly through the body. More-

over, to increase the oxygen in the blood itself, the rate of breathing is quickened. After a brisk walk or a short run you must have felt the heart beating more rapidly. You also must have noticed at the same time that you are breathing much faster than before. Physical exercise of any form, is but muscular contraction of the various parts of the body. It serves to increase the heart action and leads to an improved circulation of blood in the different organs of the body. The improved circulation carries a better supply of food and oxygen to the various organs and thereby improves their health and vigour. Further any waste matter produced in an organ as a result of its activity is prevented from collecting in that organ and poisoning it; but is rapidly washed off by the quick flowing blood stream. Hence the great value of physical exercise.

In physical exercise, due to the vigorous contraction of numerous muscles, there is an increased demand for oxygen. This demand cannot be satisfactorily met in a closed room, where we are compelled to breathe over and over again the same confined air. In the open, however, there is an abundance of fresh air from which the system can obtain all that it requires. Exercise and preferably open air exercise is thus highly conducive to health.

Muscular Fatigue.—Every muscle, when it contracts produces a slight amount of a feeble poison. This is, however, not injurious; for as soon as it is formed it is tendered harmless by oxidation. The oxygen from the blood stream combines with it and it is converted into carbon-di-oxide and water. This is what happens when the muscles in the body contract leisurely, as for instance when you take, say, a leisurely evening walk.

When, however, the muscles contract quickly and vigorously, as when one is running a race, the poisonous matter produced is considerable, and all of it does not undergo

immediate oxidation, as the oxygen available in the blood is insufficient for the purpose. The excess of poison irritates the nerves in the muscles, and immediately pain in the muscles, is felt. You must have experienced this pain sometime or other even after a long walk.

If, as soon as the pain is felt, you stop further muscular exertion, the excess of poison is gradually oxidised by the renewed supplies of oxygen in the circulating blood. Thus the rest gives the necessary relief.

If, on the other hand, notwithstanding the muscular pain, the muscular exertion is persisted in, as when a person strains to win a race, the poison produced is so great that it poisons the ends of the nerves in connection with the muscles. When the nerve-endings are poisoned, they can no more, till the poison is removed, conduct to the muscle any message from the brain. When no messages are received, the muscles stop contraction. This is what happens to the man who is straining to lead in a race which is too much for him. He may desire to run fast, but his legs fail, and he falls down exhausted.

When muscles which have vigorously contracted for a time fail to contract any further, they are said to be fatigued. The cause of muscular fatigue is the poison generated in the muscles poisoning the nerve-endings.

Fortunately, the action of the poison is but temporary. A period of rest restores the man. During the rest the poison is mostly oxidised by the renewed supplies of oxygen in the flowing blood. A small part of the poison which may escape out of the muscle fibres is washed off by the blood stream. As soon as the poison is removed, the muscles can contract again.

Two points become clear, firstly that the cause of muscular fatigue is a poison produced in the contracting muscle, secondly that oxidation of the poison is the method adopted by the system for getting rid of the poison and its effects.

Then it naturally follows that if we could contrive methods for accelerating this oxidation, then we should be more quickly able to get over the effects of the poison, *viz.*, the pain in the muscles and the muscular fatigue.

It is a matter of common knowledge that after a quick and tiresome walk, the calf muscle and other leg muscles are painful. The simple remedy adopted is to foment the leg with towels dipped in hot water. As soon as this is done every one who has tried this simple treatment will have felt a most refreshing sensation, the pain rapidly subsiding. The question is: what has warm water to do with muscular pain? They are apparently so unconnected. The explanation is that the warmth applied leads to the widening of the arteries in the muscles. More blood flows into the muscles. More blood means more oxygen and more rapid oxidation of the poison. Hence the relief.

Supposing there is one who has run a race and has finally fallen down panting hard for breath with his leg muscles stiff and painful. Can he have any other remedy? He can have immediate relief if he is given pure oxygen to breathe. The blood then takes in a much larger quantity of oxygen and the extra oxygen in the blood will quickly oxidise all the muscular poison and immediate relief can be had.

A person who has fatigued himself by vigorous muscular action is said to be physically fatigued.

CHAPTER IV

THE CIRCULATORY SYSTEM

The blood.—A drop of blood from your body seen with the naked eye is just a drop of red liquid and nothing more. But if you examine a small drop under the microscope you will find that it is composed of a colourless liquid in which float an enormous number of minute solid

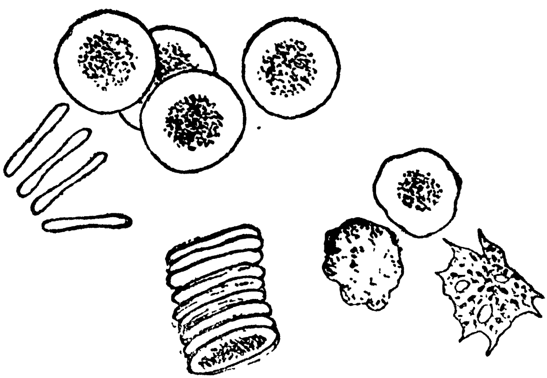


Fig. 20. **Red and white Corpuscles.**

bodies. The solid bodies are the blood cells or *Corpuscles*, and the liquid in which they float is known as the *Plasma*. The blood cells are of two kinds. One kind, which forms the vast majority, consists of little circular discs looking like minute coins. These are known as *Red Corpuscles*. Each red corpuscle looks pale yellow, but a crowd of them looks red. There will be about 5,000,000 of these in a small drop of blood, and the red colour of the blood is due to the presence in it of such a vast quantity of red corpuscles. The other corpuscles are known as *white*

corpuscles. For every four or five hundred corpuscles there is only one white corpuscle present. The white corpuscles have no permanent shape. They continually alter their shape after the manner of a minute fresh-water organism called Amoeba. The blood is thus composed of a liquid part called the plasma and a solid part consisting of red and white corpuscles.

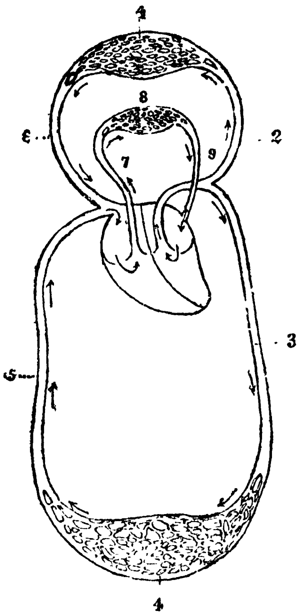


Fig. 21. **Diagram of general circulation.** 1. Left ventricle; 2. Artery to head; 3. Artery to trunk and limbs; 4. Capillaries; 5. Vein from trunk and limbs; 6. Vein from head; 7. Pulmonary artery; Lung capillaries; 9. Pulmonary vein.

Circulation of the blood.—This wonderful fluid is always circulating in the body without a moment's rest, day in and day out, through a stem of closed pipes known as blood tubes or *blood vessels.* There is a pump called the *heart* situated in the chest which keeps this fluid ever circulating. The heart, a hollow sac of stout muscle, pumps the blood into a large tube called the *Aorta* which during its course, gives rise to numerous branches, called *arteries.* The arteries carry the blood to every part of the body. When a small artery has reached a tissue (for example, a muscle), it branches repeatedly and gives rise to a net-work of extremely fine tubes known as capillaries (from Latin capilla, meaning hair), so fine that you cannot see them without the aid of a microscope. Every part of the muscle is penetrated by these capillaries which

finally open into slightly larger tubes, called *veins,* which carry the blood heart-wards. The veins returning blood

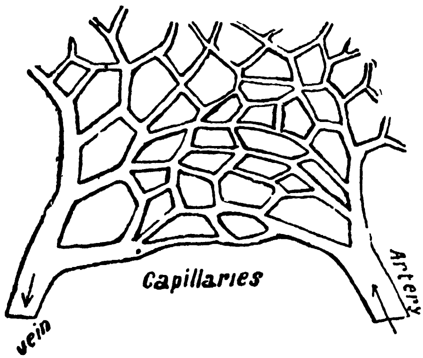


Fig. 22. **Capillary net-work.**

from different parts of the body unite to form larger and larger veins till finally, two larger veins are formed which pour the blood back into the heart. The heart pumps the blood again into the arteries. The arteries carry the blood again to different parts of the body and the veins bring the blood back again to the heart. Thus the blood is kept on circulating without a moment's rest.

The heart, the arteries, the capillaries, and the veins together form the *circulatory system.*

The Heart.—Let us study the heart a little more closely. It is a hollow sac, shaped like a cone and about the size of your closed fist. Its wall is composed entirely of muscles. The pointed end of the heart abuts against the chest wall between the 5th and 6th ribs, a little to the left side of the middle line. The inside of the heart is completely divided into two halves, a right and a left, by a fleshy partition. Each half is again divided into two chambers, an upper chamber, called the *auricle,* and a lower chamber, called the *ventricle.*

The auricle of each side communicates with the ventricle of the same side by an opening in the partition wall between them. This opening is provided with a curious door (valve) which allows the blood to flow in one direction only, namely, from the auricle to the ventricle, but *not from the ventricle to the auricle.*

The two auricles of the heart *receive* blood brought to them by veins and drive it immediately into the ventricles. The

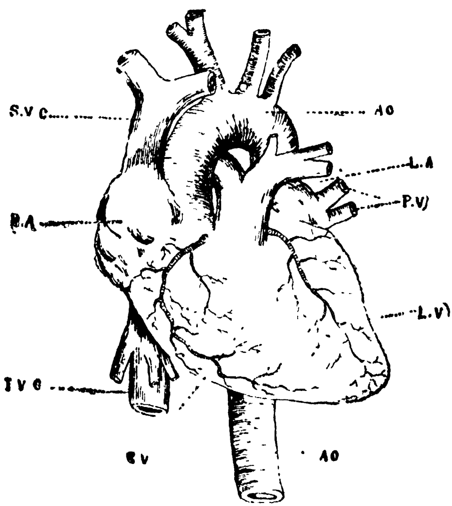


Fig. 23. **The Heart.** S.V.C., I.V.C. Veins from head and trunk; R.A. Right auricle; R.V. Right ventricle; P.A. Pulmonary artery; P.V. Veins from lungs; L.V. Left ventricle; Ao. Aorta.

right auricle receives *impure* blood brought by two large veins from all parts of the body, and the left auricle receives *pure* blood brought to it by veins from the lungs. The ventricles are the *pumping* chambers. The right ventricle pumps impure blood (poured into it from the auricle above) into a stout tube called the *pulmonary artery* which carries it to the lungs. The left ventricle pumps

pure blood (poured into it from the auricle above) into a very stout tube, the *Aorta* which distributes it to all parts of the body. Both the pulmonary artery and the aorta have, at their beginning, valves which prevent the blood from flowing back into the heart.

You may be wondering how the pumping is done by the heart. It is a simple process. You have already learnt that muscles have the property of contraction. When the stout muscular walls of the heart contract, the blood contained in it is squeezed out of it through the aorta and the pulmonary artery. The very next moment the heart dilates and gets filled again with blood. It again contracts and the blood is again forced out of it. Thus the heart does its work, night and day without any rest. You know that you can contract your biceps muscle whenever you want to, but you cannot do so with the muscles of the heart. The heart goes on contracting at regular intervals whether you wish or not. The muscles of the heart are not, like the biceps, under the control of the will.

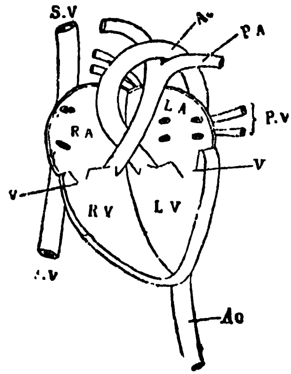


Fig. 24. **Diagram of the heart.** R.A., Right auricle. L.A., Left auricle. R.V., Right ventricle. L.V., Left ventricle. S V., Vein from head. I.V., Vein from trunk. P.V., Pulmonary veins. P.A., Pulmonary artery. Ao., Aorta V., Valves.

The walls of the heart vary in thickness according to the work that each part of the heart has to do. The auricles have rather thin walls, for they have only to force the blood into the ventricles. The right ventricle has a slightly thicker wall because it has to drive the blood to the lungs. The left ventricle has the stoutest wall, for it has to pump blood through the *aorta* to every part of the body.

Let us now try to follow one complete course of blood circulation starting from the left ventricle. This chamber gets filled with pure blood. It contracts. This valve between it and the auricle above suddenly closes, and the blood is driven into the aorta. The branches given off by the aorta carry the blood to all parts of the body. From the small arteries the blood passes through net-works of capillaries in every organ and tissue and is at last returned to the right auricle by two large veins. The blood is now impure. It is dark purplish in colour, whereas the blood pumped into the aorta was pure and bright red.

Let us here pause a little and find out how the blood became impure and where. I must here tell you something about the work of the red corpuscles, of which you have in your body about 25,000,000,000,000! You know that no animal can live without oxygen. Every cell and tissue in the body requires oxygen. It is the tiny red corpuscles that carry oxygen to every cell in every part of the body. These corpuscles have a great liking for oxygen and they readily suck it up whenever they come in contact with it. Wonderfully enough, they also part with the oxygen equally readily. When the blood travels slowly in the numerous capillaries in the wall of the lungs, it is exposed to the oxygen present in the fresh air you have breathed into them. Now is the opportunity for the red corpuscles. They load themselves with oxygen. When this blood with its oxygen-bearing corpuscles travels through the capillaries in the tissues of the body, the cells of the tissues absorb the oxygen from the corpuscles. The cells not only deprive the blood of its O but they also discharge into the blood Co_2 and other foul materials which they want to rid themselves of. We thus understand that it is while passing through the capillaries in the tissues and organs that the blood becomes impure, and it is this impure blood from the different parts of the body that is returned to the right auricle.

Before the blood is pumped again into the aorta it should be purified. The Co_2 in it should be got rid of and the red corpuscles must re-load themselves with *O*. For this purpose the impure blood is driven from the right auricle into the right ventricle and is thence pumped into the pulmonary artery which takes it to the lungs. While circulating in the capillaries of the lungs the blood loses its Co_2, gains *O* and becomes pure again. This pure oxygenated blood is carried to the left auricle by four veins and is then squeezed into the left ventricle the chamber from where we started.

We have now seen that the blood performs a double circuit—one circuit from the left ventricle through the different parts of the body back to the right auricle; and the other from the right ventricle through the lungs back to the left auricle. The heart is made up of two pumps each pump attending to one circuit, the right half of the heart pumping impure blood into the lungs and the left half pumping pure blood to the different parts of the body. The two pumps (*i.e.* the two halves of the heart) always work together without any hitch, while the right half pumps blood to the lungs, the left half, at the same time, pumps blood to the various parts of the body.

The heart beat.—The heart beats about 72 times a minute in an adult. In young boys it will be between 80 and 90 times a minute. Each heart-beat consists of a simultaneous contraction of the two auricles followed by a simultaneous contraction of the two ventricles. The beat is followed by a pause during which the heart dilates, and then the beat is repeated. If you place your ear on some one's chest between the left nipple and the breast bone you will hear two distinct sounds like lubb, dupp, during each beat of the heart.

The pulse.—At every beat of the heart, the left ventricle forces a quantity of blood into the aorta. The aorta and all the arteries are very elastic tubes. You must also remember

that they are always quite full. When, therefore, a fresh quantity of blood is forcibly driven into the already-full aorta at every beat of the heart, a further distension of its elastic wall is produced. This distension passes rapidly as a sort of wave along the whole aorta and all its numerous branches. It is this wave of expansion passing along the arteries that is known as the *pulse*. Place your finger on the radial artery in the thumb side of the wrist and feel the rhythmic rise and fall of the wall of this artery. Doctors usually feel the pulse in this artery, for it is very convenient, as it lies immediately below the skin. The rate of the pulse is the same as the rate of the heart beat.

Regulation of blood supply.—You may have noticed that your heart beats much quicker during exercise, as for instance, when you run or play foot-ball or other game. Why is this? During exercise, the muscles of your body do more work. They consume more *O* and produce more Co_2 and other waste materials. Consequently they require an increased blood supply so that they may get more than the usual supply of *O* and that they may get rid of the waste materials rapidly. It is in order to meet this demand that the heart pumps quicker and more vigorously. In the same way any particular part of the body doing greater work at one time must have more than the usual supply of blood. The stomach after a meal wants more blood. How is this demand made by a particular organ at a particular time met? Immediately after a meal, a message from the brain reaches the small arteries in the wall of the stomach. On receipt of the message, these tubes widen, and more blood flows through them. The membrane lining the inside of the stomach is usually pale, but after a meal it becomes red, due to this increased flow of blood in it. Again, when your brain is working hard, trying to solve a difficult problem, more blood is sent to the brain than when it is at rest. There is a wonderful mechanism in the body for regulating the supply of blood to the various organs according to their varying requirements.

Function of the blood.—We have already seen the important work that the red corpuscles in the blood do. They supply *O* to every cell in the body. They are the oxygen-carriers. We have also seen that the blood carries away from the tissues Co_2 and other waste materials. The

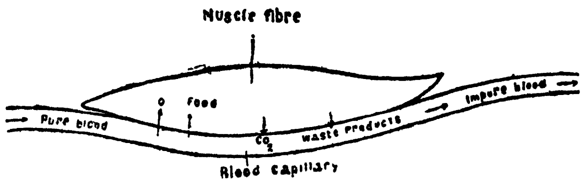


Fig. 25. Diagram to show the junctions of the blood.

Co_2 is got rid of from the body through the lungs. The other waste substances are carried by the blood to the kidneys and skin and got rid of from the body, through these organs, as urine and sweat.

The blood carries to the tissues not only *O* but also food materials for their growth. The food that we eat goes into the stomach and intestines where it undergoes many changes. The nutritious part of the food passes in the form of solutions into the blood vessels lying in the wall of the intestines. The blood carries this nutriment to every cell in the body.

As the living cells throughout the body in every tissue and organ have always to be supplied with *O* and food, and as the foul matters formed in them have constantly to be removed, you see how necessary it is that the blood, which is in charge of these duties, has always to be circulating. And we have already seen how it is kept circulating by the activity of that wonderful mechanism, the heart.

The white corpuscles.—So far, we have not mentioned anything about the work of the white corpuscles. They perform a piece of work which can by no means be ignored. The white corpuscles are the policemen and the scavengers of the body. They defend the body against disease germs.

When noxious germs enter the body, the white corpuscles crowd to the spot, passing out through the walls of the capillaries if necessary, attack the germs and eat them up. Sometimes they find their task too difficult and get killed in

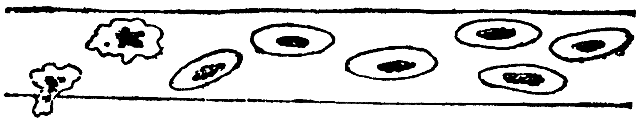


Fig. 26. **The white corpuscles** passing out of a capillary in the Frog.

large numbers, the invaders getting the upper hand. Pus from a boil consists largely of the dead bodies of such white corpuscles that have got killed in their attempt to crush the invading germs.

The clotting of blood.—When blood is shed it changes from a liquid state to a jelly-like solid. This is known as clotting. If you cut your finger and the cut is not very deep, a clot is soon formed on the wound, and serves as a plug for the cut vessel, preventing further bleeding. Clotting is nature's method of arresting bleeding.

CHAPTER V

THE RESPIRATORY SYSTEM

All of us breathe. We cannot live without breathing. We breathe from the moment we are born till we die. Breathing or respiration consists of two processes, namely, the taking in of air into the lungs *(inspiration)* and the sending out of air from the lungs *(expiration)*. An adult breathes about seventeen times a minute. You young boys breathe a little more per minute, and little children of one or two years of age breathe about forty times per minute.

Air passages and the lungs.—Let us first understand how we breathe and the passages through which the air breathed in travels. We take in air through the nose—I know that some of you breathe through the mouth, a very bad habit indeed!—and breathe out through the nose. The air drawn in through the nostrils goes into the two nasal chambers placed above the mouth cavity. The two nasal chambers are separated from each other by a thin bony longitudinal partition and each chamber has three thin scroll-like (roll like) bones projecting into it. The wall of each chamber and the three scroll-like bones in it are covered by a thin skin known as mucous membrane. This membrane is so called because it always secretes a slimy fluid (mucus) which keeps it and the chambers moist. Running in the mucous membrane are numerous tiny blood vessels. You know that blood is warm. The blood in these blood vessels keeps the nasal chambers warm, and we have just seen that they are kept moist. The nasal chambers are thus moist and warm.

The air around us usually contains minute dust particles. If we breathe air full of dust particles, we get disease. The hairs at the entrance of the nostrils are of use in catching

the dust particles and preventing them from getting in. The air thus strained passes through the nasal chambers and is made moist and warm. If the air taken in is dry and is not moistened it will dry up the moist internal surface of the lungs.

Again, if the air breathed in is cold and is not warmed, it will produce a chilling effect. See therefore, what wonderful safeguards have been provided by nature !

At the back part of the roof of the mouth, the two nasal chambers open into the throat. The air goes down the throat into the wind pipe, a tube which passes down the neck in front of the food pipe (gullet). The upper end of the wind pipe is wide and has walls of cartilage. This part can be easily felt with the finger and is the voice-box. It is also known as the Adam's apple. At the top of the

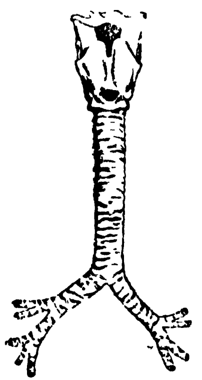


Fig. 27. **The wind pipe.**

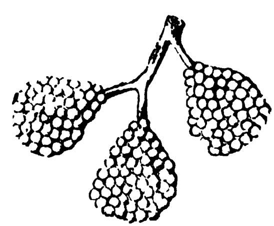


Fig. 29. **Air-sacs.**

chest, the wind pipe divides into two branches, the right and the left. Each of these divides repeatedly into smaller and smaller branches till at last the branches are very fine. Every one of these smallest branches ends in a cluster

of tiny, thin-walled, elastic sacs called *air sacs,* each cluster resembling a minute bunch of grapes. The number of air sacs in the human lungs is said to be about 725,000,000! The numerous tiny branches of the wind pipe on each side, and the air sacs in which they end are all bound together into a spongy mass. It is this spongy mass that is known as the lung. The two lungs and the heart placed between them fill the cavity of the chest.

It is, of course, necessary that the wind pipe should always remain open, and for this purpose, the wall of the windpipe is strengthened by a series of hooplike rings of cartilage. These rings are, however, incomplete at the hind side of the windpipe where the gullet is in contact with it. This is as it should be for, if it were not so, the stiff windpipe will interfere with the passage of food down the gullet. All the branches of the windpipe, except the very smallest, are supported by cartilage.

At each inspiration, the air drawn in through the nostrils goes down the windpipe and passing through its numerous branches, fills all the countless tiny air sacs.

Respiratory Movements.—Respiration is practically an unconscious process. You do not worry or think about it. It goes on without your being even aware of it. You find the chest alternately expanding and contracting and the abdomen swelling and falling. You may be under the impression that the chest expands because the lungs get filled with air. That is not so. The lungs get filled with air *because* the chest expands. Let me explain. The chest is an air-tight chamber in which are placed the lungs which communicate with the outside by the upper end of the windpipe. Further, the lungs are in close contact with the chest wall. You will agree, then, that if the chest cavity is made to increase in size by some means, the lungs also will expand with it. When the lungs expand, a partial vacuum will be created in them, and, as a consequence, air from outside will immediately rush into them. This is

exactly how inspiration is caused. We do not draw in air and so increase the size of the chest, but the chest expands first and so air rushes into the lungs from outside. How does the chest increase in size? Passing obliquely from rib to rib are two sets of muscles, an outer layer and an inner layer. (See fig.) When the outer layer of muscles

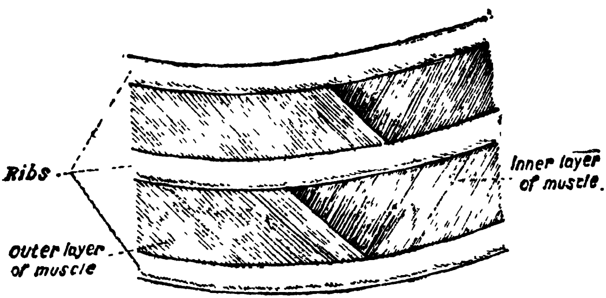


Fig. 29. **Muscles connecting rib.**

contracts, the ribs are pulled up from their slanting position to a more or less horizontal position. The chest wall will now enclose a wider space than before. Thus the chest cavity is enlarged. Again, when the ribs are pulled upwards, the breast bone which is attached to them is slightly thrust forwards. This increases the size of the chest from behind forwards. Lastly, the arched diaphragm contracts and flattens, pressing down upon the liver and other abdominal organs. This increases the length of the chest cavity. In this way the chest cavity increases in size in all directions. The lungs expand with the chest and air from outside rushes into them. This is *inspiration.*

Now the rib-muscles relax, and the ribs and the breast bone fall back to their original position. The muscular wall of the abdomen contracts pressing the liver upwards and the diaphragm becomes arched again. The chest cavity is thus decreased; the elastic lungs recoil, and the foul air from the lnngs is driven out. This is *expiration.*

Why we breathe.—Having learnt something about the mechanism of breathing, let us now understand why we breathe. You have already learnt that no animal can live without oxygen. Every cell in your body requires O_2, so that it may live and do its work. Every living cell in the body does some work or other. For doing work energy is required. The cell gets the necessary energy by the oxidation of a part of its substance. When the cell substance combines with O_2, it splits up into simpler substances, liberating energy. Every cell in the body is thus in a state of slow combustion (burning) every moment of our life.

A piece of wood has in it plenty of stored-up energy. When the wood is burnt, O_2 of the air combines with the wood and the energy in the wood is set free as heat and light. In the same way the food that we eat contains stores of energy. The food is digested, absorbed and carried by the blood stream to the different parts of the body. The cells of the tissues take up this food from the blood. While some of the food is used up by them to build up fresh cell substance, a great portion of it is used as a source of energy. The muscles, you know, are always setting free energy in the form of work and heat. This energy is obtained by the combustion of the food brought to them by the blood. For this combustion of the food O_2 is necessary.

It is therefore, for supplying every cell and tissue in the body with O_2 that we breathe. We have already seen in a previous chapter how the red corpuscles of the blood carry O_2 from the lungs to every part of the body.

Changes in the air in the lungs and in the blood during respiration.—On the thin wall of every one of the countless tiny air sacs of the lungs, there is spread out a net work of fine capillary blood vessels given off by the branches of the pulmonary artery. The blood in these capillaries is impure. It is rich in CO_2 and poor in O_2. When

the air sacs get filled with fresh air during each inspiration, an exchange of gases takes place between the blood in the capillaries and the air in the air sacs. Oxygen from the air sacs *diffuses* into the blood and is caught up readily by the red blood cells, and CO_2 and other impurities for the blood diffuse into the air sacs. The blood is now pure again. This purified blood is carried to the heart to be pumped to the different parts of the body The air in the lungs has become foul It has lost some of its O_2 and has gained in CO_2. This foul air is breathed out The expired air is very much different from the inspired air as the following table will show.

	Inspired air	Expired air
N	79·00	79·00
O_2	20·90	16·45
CO_2	·04	4·50
Water vapour	Varying amounts	Larger amounts
Organic impurities	Nil	Present

The expired air, besides containing less O_2 and more CO_2 than the inspired air, is warmer and is saturated with moisture.

Correct breathing and breathing exercises.— We have seen, that when we breathe through the nose (which is the correct thing to do), the air is strained of dust particles and is warmed and moistened before it enters the lungs. You see, therefore, how neccessary it is to breathe through the nose. There are some boys and grown-ups too, who breathe through the mouth. This is very bad habit and is injurious to health, for if you breathe through the mouth, the air is neither strained, nor heated nor moistened. Breathing through the mouth has several other disadvantages also. Look at this picture

of a boy who habitually breathes through the mouth. Note his projecting lip and the poor expression of his face. By constantly breathing through the mouth, you lose the sense of smell. You cannot distinguish odours. More than these, you become weak and unhealthy. You develop sore throat and lung troubles and you grow mentally dull.

Fig. 30. A boy who breathes through the mouth.

At times when you catch cold, the nasal chambers get badly blocked with mucus, and you find it difficult to breathe through the nose. But you must resume breathing through the nose as soon as the cold has passed off. Very often, the cause of mouth-breathing among boys is a sort of fleshy growth called 'adenoids' on the wall of the throat at the back of the nasal chambers. In such cases a medical man should be consulted, as the growth can be easily removed by him.

In ordinary breathing we do not take in as much air as is necessary to fill the lungs completely nor do we empty the lungs completely at each expiration. There is always some old air left in the lungs, and the fresh air that we breathe in is mixed with this old air. Just as we ventilate our rooms by driving out from it all the old air and filling it with fresh air, so is it necessary to ventilate our lungs too. This can be done by deep breathing. Draw in *slowly* through the nose as much air as possible, keep it in the lungs by holding the breath for a few seconds and expel it from the lungs slowly and as completely as possible. By regularly following a system of breathing exercises and practising them for a few minutes every day you can gradually increase the breathing capacity of your lungs. You will then be able to take in more air, even in ordinary breathing, and to empty the lungs more completely than you do now.

Ventilation.—We have already learnt that the air which we breathe out is foul and unfit to be taken in again. But this is what you are obliged to do when you sit or sleep in crowded, ill-ventilated rooms. As the oxygen in the room is needed by the number of people in it, it is soon used up and the room gets filled with the foul air breathed out by the people. You are obliged to breathe this foul air again and again, while the body is all the time craving for fresh air. You feel drowsy. You begin to yawn repeatedly. Yawning is an indication that the body is hungry for fresh air. You get headache and sometimes you even faint. You see therefore, how necessary it is to change the air in our rooms constantly in order to keep it fresh. The windows and doors of your class rooms are large and you see that they are always kept open, for a number of boys have to remain in them for a good portion of the day. The rooms in which you study and sleep should be well ventilated. The windows of your sleeping room must be kept open. It is dangerous to sleep in a room with the windows all closed and with a lamp burning in it. A kerosene light or a candle light gives out as much CO_2 per hour as one man. If your sleeping room is not properly ventilated, a good place to sleep in would be the open verandah of the house. How active and springy we feel on rising from our bed, having slept in a place with plenty of fresh air about us! Night is the time when our muscles, our brain and our nerves which have been working throughout the day are having rest. They should be allowed plenty of fresh air, so that they may again work with vigour the next day.

How air gets contaminated.—The air around our houses gets foul in several ways. The rubbish carelessly thrown about everywhere on the premises, the badly-kept latrines stinking with bad odour, the dung heaps from the stable or the cowhouse, the rotting vegetation, all these serve to vitiate the air. It is very essential to keep the premises *absolutely clean* in order that the air around our

houses may be fresh. It is also our duty as citizens of a town to keep its streets clean. There is, of course, the municipality to look after the sanitation of the town, but we must co-operate with it and do our bit individually. People throw rubbish about the streets instead of placing them in the receptacles kept for the purpose. More disgraceful than this is using public streets as latrines, not only by little children but even by adults.

Dust also contaminates the air. Dust is not only a nuisance but a danger to public health; for bacteria, some of which are harmful and cause disease, are often present associated with particles of dust. It is one of the primary duties of municipalities and Public Health Departments to prevent or at least minimise dust in towns by tarring the roads or by otherwise keeping them in good condition. People who breathe dust get weak lungs and develop lung diseases.

We should also keep our houses free from dust, though it is a job doing it, if we happen to live near a public road. Every room in the house should be daily cleaned with a moist cloth. Floor mattings and carpets are but dust traps and should not be used. Bare floors kept absolutely clean are the best. All articles of furniture should also receive frequent attention as they too serve as traps for dust.

Advantages of an open air life.—Fresh air is like a tonic to the body. It invigorates and makes us healthy. Look at the robust people working in the fields right through the day and look at the hollow-chested, weak-bodied men who are obliged to sweat in crowded, ill-ventilated office rooms and dingy godowns and who hardly spend any time in the open. The people who habitually remain indoors are more susceptible to disease than those who spend at least some time every day in the open. It is essential that we should spend at least one or two hours everyday in the open air. It is for this purpose that parks are provided for people in crowded cities. In some schools

in India, where grounds are available, classes are sometimes held under shady trees, the children all seated on the grass. The depression that you sometimes feel in the close class-room will be absent here. One or two open-air classes should be held every day in schools where facilities exist. Make it a rule to spend some time everyday out of doors breathing the fresh air, and you will have less attacks of coughs and colds and you will be less susceptible to several diseases caused by weak lungs. The value of open air for people suffering from lung troubles has been so much recognised that special homes are built for them by the Government and private agencies, in open places where they can enjoy plenty of fresh air and sunlight.

Sunlight is as much essential as fresh air. Houses are sometimes constructed in streets in which not one ray of sunlight could enter. This is very wrong. Our rooms should be light and airy and direct sunlight should have access into the house.

Sunlight, besides brightening the surroundings is a wonderful germ-killer. It is a good plan to expose our clothes, mattresses, pillows, etc. to the sun as frequently as possible. Exposing ourselves to direct sunlight for a few minutes, everyday is also very desirable.

CHAPTER VI

THE DIGESTIVE SYSTEM

Why we eat.—The human body is a wonderful machine. Unlike other machines the parts of this machine *grow* in size, for about twenty-five years. You are young and your bodies are growing in size. In order that the parts of the body may grow, new material is required. A muscle cannot grow unless new muscle material is added to it. A bone cannot grow unless new bone substance is added to it. The new materials necessary for the growth of the body are provided by the food that you eat.

Again, both in the case of boys who are growing and in the case of older people who have ceased to grow, some or other parts of the body are constantly doing work. Even when you are quietly lounging on a sofa, several parts of your body are actively doing work. Your heart is pumping blood to the different parts of the body, your lungs expand and contract, your food tube is busy digesting the food that you have taken, your kidneys are filtering the blood of impurities, and your brain, besides directing and controlling the of wokr all these organs, is perhaps thinking about the foot-ball match you witnessed the previous evening. When any part of the body does work, it does so at the expense of its own material, just as a candle that gives out flame does so at the expense of its wax. When a cell does work, a part of the cell substance undergoes oxidation and destruction. There is a loss of the cell substance. Thus every cell in the body is constantly losing material. This constant loss of material from the body has to be made good.

Again, when doing work we expend evergy. Energy is required for performing any sort of bodily movement,

whether external or internal. Where is this energy from? It is from the oxidation of the food. ' The food that we take contains stores of energy derived from the light and heat of the sun by green plants. During oxidation it is not only energy that is liberated but heart is evolved. Though heat is constantly lost from your body, it is always kept warm.

We now see that we take in food for the following purposes:

(1) to provide the body with materials necessary for its growth and for replacing the daily loss from it and (2) to supply the body with heat and energy.

The body and its needs.—Our body is built up of different kinds of tissues, such as, muscle, connective tissue, blood, etc., and each kind of tissue is composed of a particular type of cells. The body is thus an aggregate of different kinds of cells. What are the cells made of? The cells are composed of a living material called *protoplasm*. The body of every animal is composed of this wonderful living substance, packed up in millions and millions of tiny cells. Protoplasm is not only very complex in its composition, but it is very unstable, breaking up readily into simple substances. Protoplasm consists chiefly of *proteins*, the most important constituents of which are Carbon, Hydrogen, Oxygen, Sulphur, Nitrogen and Phosphorus.

As the body cells are composed of proteins, the chief needs of the body are proteins. *Proteins* are required for replacing the loss of material from the cells and also for their growth. *Mineral salts* are also required by the body as these enter largely into the composition of bones. They are are also present in the muscles and other soft tissues of the body and in the blood. Proteins and mineral salts are the chief *tissue builders*. *Carbohydrates* are substances composed of Carbon, Hydrogen and Oxygen. Starch and

Sugar are carbohydrates. *Fats* are also compounds of the same three elements. Both Fats and Carbohydrates are necessary for the body in order to supply it with heat and energy, and these are, therefore, called *fuel foods*. Fats are more important as fuel foods than Carbohydrates. The excess of fat used in the food is stored in certain parts of the body, as for instance, under the skin, to be used in times of need.

Water is also essential for the body. The body is largely made up of water and since large quantities of water are lost everyday from the body, as sweat from the skin, as urine from the kidneys, and as moisture from the lungs, we need to drink plenty of water.

Vitamins.—It has been recently discovered that, in addition to the substances mentioned above, the body needs another class of substances called *vitamins*. These occur in extremely small quantities in certain foods and they are all of vegetable origin. They are so essential to life that their absence or deficiency in our foods causes disease. The nature and composition of these substances are still not well known and it has not been possible to isolate them. Three different vitamins have been discovered and these are called A, B, and C vitamins. The foods that contain these are mentioned below, and it is necessary that we include, in our daily diet, articles of food containing them.

A. Vitamin (Fat soluble).—This vitamin is present in butter, ghee, yolk of egg, meat, milk, green leafy vegetables, fat fish and in *cod-liver* oil.

B. Vitamin (Water soluble).—This is present in ragi, oats, wheat, peas, beans, dhals, fresh potatoes, onions and whole rice (not milled).

C. Vitamin (Water soluble).—Is present in fresh sprouted peas, dhals and gram; orange, fresh lemon and pine apple.

Our common articles of food contain all the substances required by the body, each article containing one or more of the substances in varying amounts. The composition of some of the common articles of food is given below.

Protein, Carbohydrates, fats aud vitamins of a few common articles of food in 100 parts.

Food		Proteins	Carbo-hydrates	Fats	Vitamin A	Vitamin B	Vitamin C
Unpolished Rice	...	8·05	78·05	0·3	...	+	...
Polished Rice	...	6·26	91·31	0·4	...	...	...
Wheat	..	13·6	71·2	1·9	+	+*	...
Ragi	...	9·7	81·7	1·6	+	+	...
Dhals	...	22·7	56·7	3·4	+	+*	...
Grams	...	19·9	53·5	4·5	+	+*	...
Goats' meat	...	25·2	...	2·6	..	+	...
Egg	...	13·2	...	10·3	+*	+*	...
Butter	...	...	...	80·8	+*	...	...
Cod-liver oil	...	...	...	98·00	+*	...	...
Cow's milk	...	3·3	4·7	3·6	+*	+*	+
Human milk	...	1·4	2·6	5·2	+	+	+
Brinjal	...	1·2	5·0	0·3	..	+	+
Ladies fingers	...	1·9	5·9	1·5	...	+	+
Plantains	...	1·6	8·0	0·1	...	+	+
Oranges	...	0·8	9·4	0·1	+	+	+*
Lemons	...	0·5	3.08	0·5	...	+	+*

Choice of a good diet.—It is difficult to prescribe an ideal diet, since the quantity and the quality of the food required by each individual will depend on several factors, the chief of which are the age of the individual, his occupation, the climate of his place, etc. It is essential that the food should contain all the substances required by the

+ Means 'some' + *Means 'rich'

body and, as far as possible, in the proportions needed by the body. It has been estimated that an average adult loses in a day about ½ oz of N. by the kidneys, 8 oz of C. in the form of CO_2, and about 60—70 ounces of water. He must make good these losses and also supply the necessary fuel for generating heat and energy. For this purpose he must take:—

3½ ounces of proteins.	1 oz of Salt and
2 ounces of fat.	70—80 ounces of water.
12 ounces of carbohydrates	

If a man lives on rice alone he has to take nearly 3½ pounds of it to make good the loss of ½ oz N. from his body. This quantity of rice contains nearly 19 ounces of carbon, whereas the loss to be made good is only 8 oz. The man who chooses to live on an exclusive diet of meat, or fruits has the same difficulty. You see, therefore, how necessary it is to include various articles of food in our diet in order to get the required quantities of all the substances. In other words, a mixed diet is necessary, so that we may be sure of obtaining all the substances that our body needs.

Since rice is the staple article of food in this presidency, and since rice is composed mostly of starch and contains very little proteins and fats, it is very necessary that we should include dhals, milk, and butter or ghee, in our daily food. Dhals and milk supply the necessary proteins. Eggs meat and fish, also contain proteins, and these animal proteins are more easily digested than those in dhals. Butter and ghee supply the necessary fats. Animal fats are richer in vitamins and should be preferred to vegetable fats such as gingelly oil, cocoanut oil, etc. Green leafy vegetables, fresh fruits and milk, will supply the necessary mineral salts and vitamins. Fruits which are ripe and fresh should be eaten. The saying "an apple a day keeps the doctor away" has a lot of truth in it. Condiments, such as, hot pickles, chutneys, rasams, etc. have no food value

but, if taken in moderate quantities, they may help digestion by stimulating the digestive glands to increased secretion. Milk is an ideal food to children till they are about 2 years old. During this stage it is not advisable to feed them on starchy foods as they cannot properly digest them. It is stated that a person should take one ounce of food for every pound of his body weight, with the food stuffs in the following proportion :—

Proteins	100	Carbohydrates	315
Fats	65	Salts	23

Children should of course, take more food for every pound of their body weight, for their bodies are growing, and food is required by them not only for repairing the tissues but also for their growth.

Coffee and Tea.—Coffee and tea are not foods but stimulants. Used in moderation, they are not harmful, but taken in excess they do a great deal of harm by acting injuriously on the nerves, heart and digestion.

CHAPTER VII

THE DIGESTIVE SYSTEM *(Contd.)*

Alimentary canal and its parts.—The food that we eat must pass through the wall of the food tube into the blood vessels lying in it, so that it may be carried by the blood to every part of the body. The greater part of our food is solid and insoluble. The food must, therefore, be made thoroughly soluble before it can pass through into the blood. The process of converting the food into solutions and thus rendering them fit to be absorbed by the blood vessels is called *digestion*. Digestion is effected in the alimentary canal. The alimentary canal or food-tube is a long tube, about 30 feet in length, and it begins at the mouth. The mouth leads into the throat—which opens downward into the gullet. (We have already seen that the windpipe from below and the nasal chambers from above also open into the throat). The *gullet* is a muscular tube, about nine inches long, and is like the rest of the alimentary canal lined by mucous membrane. It lies behind the wind pipe and in front of the vertebral

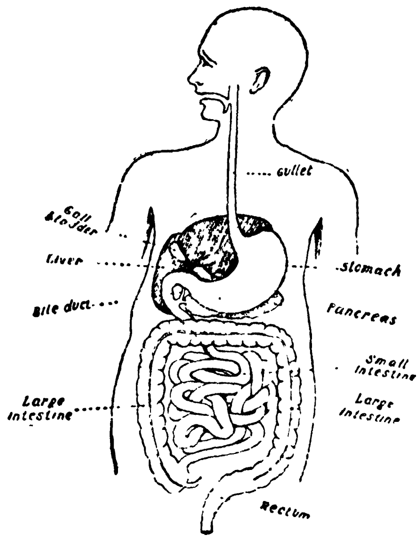


Fig. 31. **The Alimentary Canal.**

column. The gullet runs down the chest and passing through the diaphragm expands into a large oval, muscular bag called the *stomach,* in the left side of the abdomen. The wall of the stomach is lined inside by mucous membrane. The right side of the stomach is narrow and opens into a tube called the *small intestine,* which is about 20 feet long and 1 inch wide, and lies coiled up in the abdomen below the stomach. The opening between the

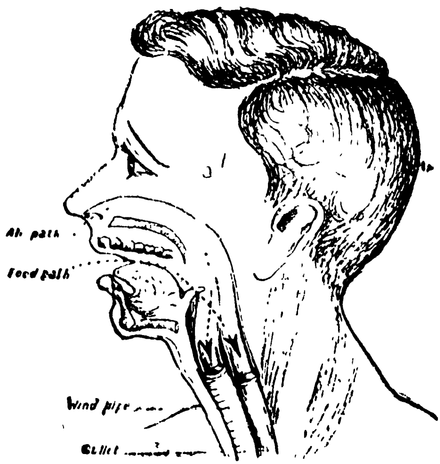


Fig. 32. The upper parts of the air-path and the food-path.

stomach and the small intestine is surrounded by a ring-shaped muscle. When this muscle remains contracted, the opening is kept closed. When the muscle relaxes, the opening is widened, and the contents of the stomach are allowed to pass into the intestine. The first part of the small intestine, called *deodenum,* forms a U-shaped loop in which lies a very important gland, the pancreas. The mucous membrane which lines the small intestine gives off numerous minute finger-like projections known as villi.

The villi give the intestinal surface, the appearance of velvet. The end of the small intestine opens into a wide tube, *the large intestine,* at the bottom right side of the abdomen. The large intestine, which is about 5 feet long, passes up the right side of the abdomen, then across it to the left side below the liver and the stomach. It then descends along the left side and opens into a wide straight tube the rectum which opens to the outside.

THE GLANDS CONNECTED WITH THE ALIMENTARY CANAL AND THEIR SECRETION

Salivary glands.—There are six glands (3 on each side) which pour their secretion into the mouth. These are the salivary glands and their secretion is the saliva. Of the three glands on each side, one lies in front of the ear, one under the lower jaw and one under the tongue. The saliva has several uses, the most important of which is its digestive action on the food. The fluid contains a substance which has the power of turning the starch in the food into sugar. Starch is an insoluble substance. It must, therefore, be turned into sugar before it can be absorbed by the blood. If a small quantity of rice soaked in water is chewed for a long time, you can see that it becomes sweeter and sweeter, because the starch in the rice is turned into sugar by the action of saliva.

The Pancreas.—The pancreas is a long, narrow gland, situated in the loop of the duodenum. The pancreatic juice which is secreted by the cells of this gland is poured into the duodenum by means of a short duct. The pancreas does not prepare its secrtion always, but only when it is required for digestive work. The juice contains three important substances which act on the three different food stuffs, namely, fats, starch, and proteins, and make all these fit for absorption by the blood.

The liver.—The liver is a large reddish-brown organ in the abdomen lying immediately below the diaphragm. It

consists principally of two lobes, a right and a left. While the greater portion of it lies on the right side, it extends slightly towards the left and overlaps the stomach. The cells of this large gland prepare a greenish yellow fluid called the bile. (The secretion of the bile is not the only function of the liver). Unlike the pancreatic juice the bile

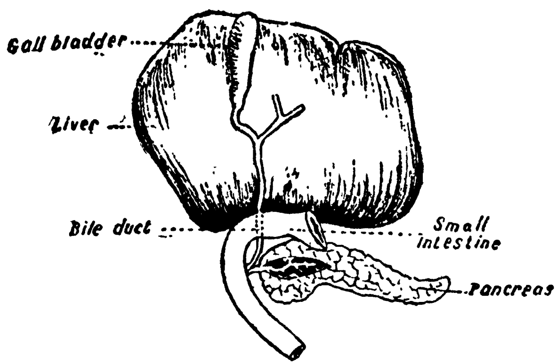


Fig. 33. **The liver and the pancreas.**

is secreted *continuously* and not only when it is required for digestive purposes. The secretion is stored in a bag called the gall bladder on the under surface of the liver, and when required it is poured into the intestine (duodenum) by means of a duct called the bile duct. The bile has no direct action on the food; but it helps the pancreatic juice in its action on fats. It is also useful in preventing putrefaction in the contents of the intestines.

In addition to the glands mentioned above, there are numerous tiny glands in the mucous membrane of the stomach which secrete an acid juice called the gastric juice. The mucous membrame of the small intestine also has in it thousands of minute glands which pour their secretion into it.

Digestion in the mouth.—As soon as you put a morsel of food in the mouth the digestive machine begins

to work. You begin to chew the food with your teeth. Saliva begins to flow into the mouth in profusion. Chewing stimulates the flow of saliva, and saliva helps chewing. The food gets ground up into fine particles and is thoroughly mixed with the saliva. The fluid changes the insoluble starchy part of the food into sugar. As a very large portion of our food consists of starch, it is necessary to keep each morsel in the mouth sufficiently long and to chew it thoroughly so that it may be well acted upon by the saliva. This was what Gladstone, "the Grand Old Man" of England, meant when he said in his humorous way that "every morsel of food should be given thirty-two bites so that every tooth might have a chance at it." 'Eat slowly and chew well' is a golden rule which you must practise.

Besides digesting starch the saliva has other uses too. It moistens the food and makes swallowing easy and it helps the movements of the tongue in speech. You know how difficult it is to speak when the mouth is dry. Saliva is thus a very useful fluid and it is not wise to waste it. Tobacco chewers spit out large quantities of saliva and thus waste it. Tobacco stimulates the glands to increased secretion and thus gradually weakens them.

Digestion in the Stomach.—The food thoroughly well chewed and acted upon by the saliva is swallowed and it gets into the gullet. The muscular walls of the gullet contract from above downwards and push the food down into the stomach. When the food reaches the stomach, the mucous membrane lining its wall becomes red, due to the increased flow of blood through its blood vessels. The numerous glands in the membrane become vigorously active and pour their secretion into the stomach and the food gets mixed with it. In order that the food may get thoroughly mixed with this secretion, the muscular wall of the stomach contracts in different directions so as to turn the food this side and that. The gastric juice acts on the portein part of the food and converts it into a soluble

form. It has no action on carbohydrates and fats. Meat, white of egg, milk, the protein parts of dhal, etc., are all digested in the stomach. The food remains in the stomach for about 3—4 hours and by this time the whole of it is changed into a creamy semi-fluid mass called the chyme.

The chyme is sent to the small intestine in small quantities at a time. When digestion has begun in the stomach, the ring-shaped muscle surrounding the opening between the stomach and the small intestine relaxes at intervals, allowing a little of the chyme to pass through. After all the chyme has passed from the stomach into the intestine, the ring muscle contracts and keeps the opening closed.

Digestion in the small intestine.—A part of the starch in the food has been digested in the mouth and a part of the proteins has been digested in the stomach. There is still a portion of the starch and proteins and all of the fats to be digested. The food remains in the small intestine from ten to twelve hours and during this time it is acted upon by three juices namely, the pancreatic juice, the bile and the intestinal juice.

The pancreatic juice contains three substances, one of which digests proteins, another converts starch into sugar, and the third acts upon fats breaking them up into fine tiny globules. If you examine a drop of milk under the microscope you will find numerous tiny globules of fat floating in it. Fat floating in a liquid as minute globules is called an *emulsion*. In the intestine fats are made into an emulsion.

The *bile*, though not a purely digestive juice helps the pancreatic juice in emulsifying fats.

The intestinal juice helps the digestion of proteins and converts the sugar already formed into a simpler variety.

The process of digestion started in the mouth is thus completed in the small intestine. The starch has been changed into a simple kind of sugar, the proteins have

been changed into simple soluble substances and fats have been made into an emulsion.

The process of absorption.—The food is made to move slowly down the long small intestine by the wavelike contractions of its muscular wall. When the food thus moves on, the digested parts of it are *absorbed*. I have already told you that there are numerous tiny projections called *villi* on the lining of the intestinal wall. In each villus there is a network of blood capillaries and a white tube called *lacteal*. The sugar and the dissolved proteins diffuse into the blood in the capillaries of the villi and are carried to the liver by a vein called the *portal vein*. The liver picks up the sugar, converts it into a kind of starch and stores it, to be sent out later to the blood as sugar, in small doses according to the requirements of the body. The liver thus serves as a bank in which the body deposits its sugar and draws from it according to its needs. The proteins circulate in the blood stream and reach every part of the body. The emulsified fats pass into the lacteals in the villi and finally find their way to the blood.

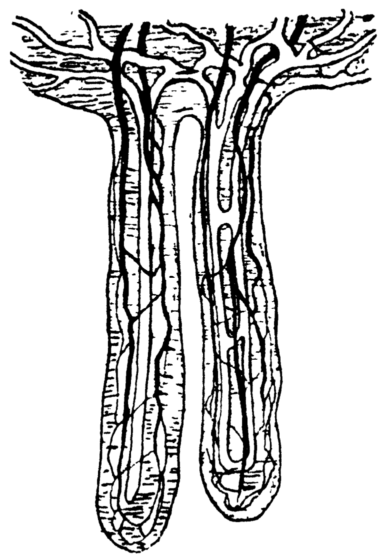


Fig. 34. **Two Villi.**

We have now seen how the food that we eat is digested by the action of the various juices prepared by the different digestive glands and how this digested food is absorbed by the blood and carried to the different parts of the body.

The undigested and innutritious part of the food is passed on into the large intestine. Some of the water from this stuff is absorbed and the contents become more solid. This solid waste matter is expelled from the large intestine as stools.

Constipation.—The waste matter from the large intestine must be expelled everyday. In the case of some people the bowels do not move regularly, with the result that the waste matter accumulates in the large intestine. This condition is called constipation. This is a common complaint among children. If faecal matter is allowed to remain long in the large intestine, poisonous products from it will pass into the blood and cause headache, loss of appetite, bad breath, etc. Constipation can be cured by regular physical exercise and by including in the diet plenty of green vegetables and fresh fruits. You are not likely to get constipation if you cultivate the habit of regularly going to stool at a stated hour once or twice a day. Though the attempt may not always be successful, the habit will be formed, and the muscles of the large intestine will acquire the habit of becoming active regularly. Strong purgatives should not be taken, as they weaken the bowels considerably.

Teeth and their care.—Teeth are very important

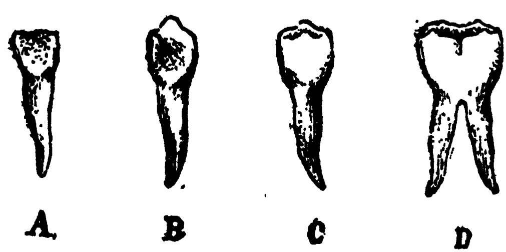


Fig. 35. The four kinds of teeth.

structures so that I must tell you something about them before closing this chapter. We develop two sets of teeth,

the milk teeth and the permanent teeth. The milk teeth are temporary and are twenty in number. They are gradually dropped one by one and permanent teeth take their place. In an adult there are 32 permanent teeth. They are not all alike but are of different forms according to the work they have to do. Teeth are intended to cut, tear and grind the food. In the front of each jaw there are four teeth with sharp chisel edges. They are adapted for cutting or biting and are termed *incisors*. Behind the incisors on each side is a more or less pointed tooth adapted for tearing. As these four teeth resemble the corresponding teeth of a dog, they are called *canine teeth*. Behind each canine tooth are five teeth with flat rough surfaces adapted for grinding up the food. These five are the *grinders* of which the two front ones are small and the three hind ones are large.

Each tooth has two parts, the part buried in the socket in the jaw bone and the visible part above. The latter is termed the *crown* and the former, *fang* or *root*. The tooth is made of a hard substance called dentine resembling bone. The dentine of the crown is covered by very hard enamel. The fangs are fixed in the sockets by a substance called cement which is very like bone. Each tooth has a central cavity filled with a pulpy substance in which are blood vessels and a nerve. There is a hole at the base of the fang through which

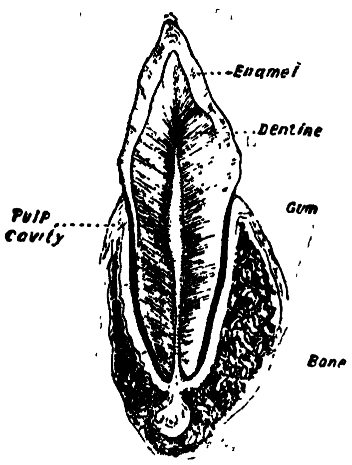


Fig. 35. Section through a tooth.

the nerve and the blood vessels enter the pulp cavity.

Teeth should be taken the greatest care of. Bad teeth are often the cause of indigestion and of general ill health. Teeth must be used so that they may be strong. Those of you who 'bolt' your food do not exercise your teeth so that they will soon decay. You must not only use your teeth but keep them clean. Teeth should be cleaned at least twice a day, once in the morning and once at night before going to bed. Particles of food collect in the narrow gaps between the teeth and also in the chinks between them and the gum. Starchy food stick easily to the teeth and the starch particles ferment and produce acids which gradually eat away the protective enamel. Sometimes germs begin to attack the teeth, and pus full of germs collects round them. The pus contaminates the food; and indigestion, lack of vitality, etc., result.

The teeth should be cleaned with a tooth brush or a 'chewed' tooth stick and the mouth should be well washed out with cold water. Chewed tooth sticks of acacia, neem, and nut stalks of the cocoanut are all quite good. The brush should be worked on both sides of the teeth *from the gum towards the edge*. An up-and-down motion of the brush will remove all food particles from the gaps. Tooth powder, if used, should not be gritty, as gritty particles tend to wear off the enamel. Powdered brick, sand, etc., should never be used for cleaning the teeth.

In all cases of tooth-ache or any other tooth trouble a dentist should be consulted.

CHAPTER VIII

EXCRETORY SYSTEM, EXCRETORY ORGANS, LUNGS

In our kitchens in our homes, we usually burn firewood in the fireplaces on which our foods are cooked. The firewood after it is burnt always leaves behind, a quantity of ash. The ash is regularly removed so that it may not choke the fireplace. The ash, as you know, is useless for burning purpose and is a simple instance of waste matter.

Similarly in our bodies, the greater part of the absorbed food undergoes burning or combustion and it leaves behind a quantity of waste matter. Just as it is necessary to clean the fireplace of the ash left in it, so also is necessary that the waste matter formed in the body should be removed.

The waste matter formed in the body is of different kinds. One of them is a nitrogenous waste matter derived from the proteins. It is called urea. Others are carbon-di-oxide and water formed principally from the combustion of fats and carbohydrates in the body.

Just as there are special organs for the digestion and absorption of the food, so also there are special organs for removing and throwing out of the body the waste matter formed in it. Such organs as are engaged in removing and throwing out the waste matter from the body are called excretory organs.

The principal excretory organs are three. They are the kidneys with their connected organs, the skin, and the lungs.

The Kidneys and their connected Organs.—The kidneys are two in number and are placed in the abdominal cavity, a little below the diaphragm, one on each side of the spinal column. Each kidney has roughly the shape of a

bean seed and is dark-red in colour. It has a length of about four inches and a breadth of about two inches. The two kidneys are so placed that the concave side of the one faces the concave side of the other. Starting from the concave side of each kidney and running down is a tube called the ureter. The two ureters open below into a muscular sac, the urinary bladder which is placed in the pelvis. From the bladder starts a single tube, the urethra which opens out.

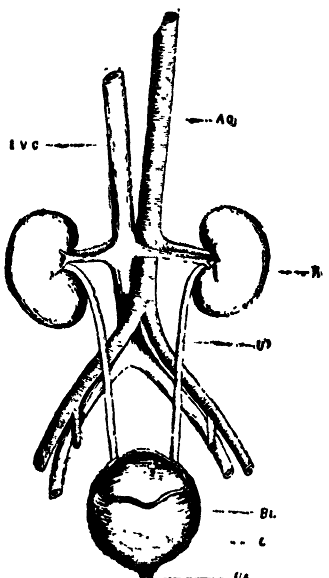


Fig. 36. The kidneys and connected organs.

Between the two kidneys run two large blood vessels, one an artery and the other a vein. From the part of the artery between the two kidneys, start two branch arteries. One branch runs into one kidney and the other into the other. From each kidney starts a vein which opens into the larger vein running between the kidneys.

The artery to each kidney runs into the substance of the kidney and branches in it repeatedly. Each small, terminal, branch artery opens into a small cluster of capillaries with a rounded shape. This spherical cluster of capillaries is called a glomerulus. The glomerulus is in connection with a small artery on one side and a small vein on the other. The little artery carries blood to the glomerulus. The blood flows through the capillaries of the glomerulus

Besides this water, we take plenty of water in our drinks. How is this water that enters the food canal, dealt with? Most of the water is absorbed and passed into the blood stream. In our foods there are also various kinds of salt

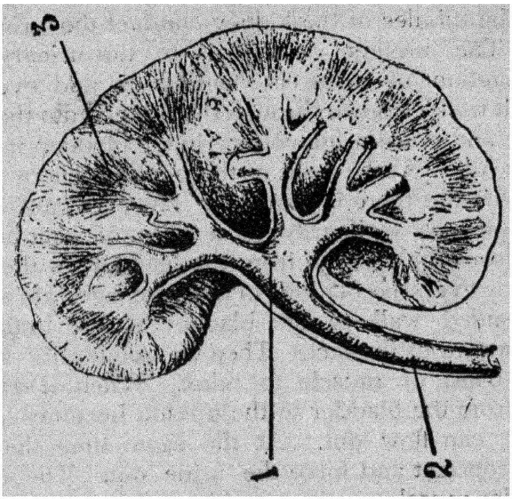


Fig. 38. **Longitudinal section of the kidney.**
1. Cavity on the concave side of the kidney.
2. Ureter.
3. Tubules opening into 1.

principally common salt. You know how every curry, or food preparation receives an addition of common salt to make it tasty. These salts, common salt and others, are also absorbed and passed into the blood stream. The blood, as you have learnt, circulates through the body flowing through each and every organ. Laden with urea from the liver, with excess of water and of salts from the food canal, the blood flows through the kidneys as well. As the blood streams through the kidneys, it runs through the innumerable glomeruli contained in them. Each glomerulus is a wonderful little filter. The

excess of water in the blood together with the excess salts in it and the nitrogenous waste *viz.*, urea oozes out through the glomerulus into the sac which encloses it. From the sac it flows into the tubule. The water with the dissolved salts and urea that filters through the glomerulus constitutes urine. The tubules of the kidney conduct the urine to the ureter. The ureters convey it to the urinary bladder. The excretion of urine is continuous, and even as it is formed, it trickles down through the ureters into the bladder. As more and more urine collects in the bladder, it gradually becomes full. At the neck of the bladder where it opens into the urethra there is a circular band of muscle. This muscle remains ordinarily in a state of contraction and thus it closes the passage from the bladder to the urethra. When, however, the bladder is full, messages are sent from he distended wall of the bladder to the brain, and we become aware of the fact. Then we voluntarily allow the circular band of muscle to relax. When it relaxes, the passage from the bladder to the urethra becomes open and the urine can flow out. At the same time the bladder muscles contract and force the urine out. The action of the bladder muscles is comparable to the action of the hand when blowing a motor horn.

The function of the kidney is to excrete the urine; that of the ureter is to conduct the urine from the kidney to the bladder, and that of the bladder with the circular band of muscle at its neck is to act as a temporary reservoir for the urine. The value of the urinary bladder may best be realised if we pause to consider what would happen, if it were absent. Then, in that case, the urine will be continuously dribbling out. The presence of the bladder with its circular band at its neck is thus a great convenience. It enables the urine to accumulate in it and demands only its occasional voiding. The function of the urethra is to conduct the urine from the bladder to the exterior.

The total quantity of urine voided in a day by a full-grown person is about 2—3 pints. The quantity is not constant but is variable. It depends partly upon the quantity of water present in the food and the drinks. By drinking plenty of water, the quantity of urine may be increased. By reducing the quantity of water taken, it may be decreased. The quantity of urine also partly depends upon the quantity of water lost from the skin as perspiration. In hot weather, copious sweating takes place, and then the quantity of urine is diminished. The same thing happens when one takes violent physical exercise and thus induce profuse sweating. In cold weather, there is only slight sweating and the quantity of urine is increased.

Whatever may be the quantity of urine, the amount of urea and salts lost in the urine remains practically constant. Daily about 1¼ oz (or about 30 grams) of urea and about an ounce of salts are lost.

The Lungs as excretory organs.—You have already learnt that the air we breathe out is richer in carbon dioxide than the air that we breathe in. Every 100 volumes of air that we exhale contains about 4 volumes of carbon dioxide; but the air that we inhale contains only a negligible trace of it. The carbon dioxide given out from the lungs of a full-grown person in a day measures about 80 gallons, and contains about half a pound of caroon. Through the lungs we lose about ½ lb. of carbon.

In addition to carbon dioxide, water is also lost from the lungs It has been estimated that about half a pint of water is daily lost from the body in our breath. It may appear strange that so much of water is lost daily without attracting our notice. The matter will, however, become clear, when we remember that if both the lungs be taken out and their inner surfaces be spread out, they

will then cover the surprisingly large area of 900 sq. ft. Over this large surface plays the respiratory current of air. The surface is also warm and moist and considerable evaporation must take place.

Through the lungs we daily lose ½ a point of water and ½ a pound of carbon.

CHAPTER IX

THE SKIN AND ITS FUNCTIONS

The skin forms a natural coat for the body and covers its entire surface. It consists of two layers, an outer and an inner. The latter is called the dermis and the former the epidermis; for it lies over the dermis. The dermis is provided with numerous blood vessels and has therefore a rich blood supply. The epidermis on the contrary is devoid of blood-vessels and has no blood supply. The epidermis is not of uniform thickness. On the palm of the hand and the sole of the foot, where it is subject to constant friction, it is thick; whereas over the rest of the body, it is thin. The epidermis

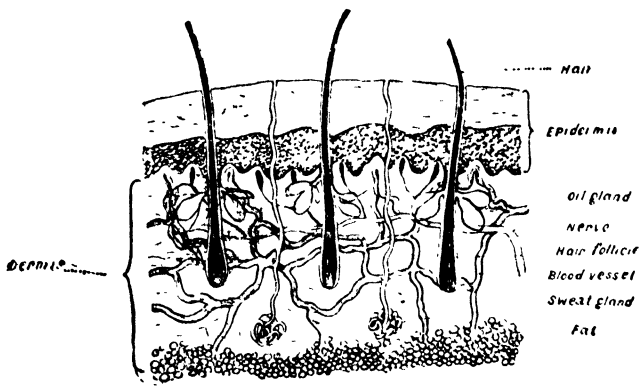


Fig. 39. Thin slice through Skin.

itself is of two layers—a deep layer and a surface layer. The deep layer rests on the dermis and its cells are living cells and they grow and multiply absorbing food materials from the blood vessels of the dermis. The surface layer

of the epidermis is removed from the dermis and has no food supply. Its cells are therefore dead. They take the form of thin horny scales. These scales are partly lost when we rub our skin while bathing. When we comb our hair, we shall notice that the teeth of the comb remove thin flakes composed of these scales. As the scales of the surface layer are lost, more are added from below from the cells of the deep layer. The scaly layer of the epidermis becomes compacted into a plate to form the nail at the tip of a finger or a toe.

Placed in the skin are numerous tiny glands, the sweat glands. Each sweat gland is a minute tube, the outer part of which runs through the epidermis; and opens out on the surface, and the inner part is closed and folded into a little ball and placed in the dermis. The latter part of the gland removes from the blood vessels with which it is in contact water with a trace of common salt, and passes it out to the surface of the skin. The water with its trace of salt so excreted by the sweat gland forms the sweat or perspiration. Each sweat gland is a minute body and singly can excrete only a slight amount of sweat, but there are about two million sweat glands in the entire skin, and it is no wonder that on a hot day or after violent physical exercise the whole body surface is drenched with sweat. The surface of the palms is particularly rich in sweat glands which here number about 3000 per square inch. The openings of these glands may be readily seen with the help of a magnifying glass or hand lens. Keep your hand closed for a few minutes till you feel that your hand is beginning to perspire. Then when you open your hand, you will see even with your naked eye numerous silvery specks dotting the surface of the palm. Examine now with the hand lens. Each silvery dot is distinct and clear and is seen within a minute depression. The latter is the opening of the sweat gland and the silvery dot, a droplet of sweat. You will notice, as your eye gets accustomed to detect these pores, that they are very

numerous and are arranged in a row on each little ridge of the skin.

Regulation of body-temperature.—It is a matter of common experience that during the hot weather, when the air is warm, we sweat profusely. How is this brought about? The atmospheric heat acts on the skin and leads to the dilatation of its arteries. When the arteries expand, necessarily more blood flows through them. The skin with its sweat gland receives more blood. When the sweat glands receive more blood, they produce more sweat. The perspiration does not remain on the body surface long; it evaporates and as it does so, it removes a considerable amount of heat from the body. Though the body temperature on account of the hot atmosphere tends to rise, it is effectively prevented by the cooling effect of the evaporated sweat. The same thing happens during violent physical exercise. Owing to the repeated contraction of numerous muscles during the exercise, considerable heat is generated in the system and the body temperature tends to rise.

At the same time, the arteries of the skin expand conveying a more abundant supply of blood to the sweat gland. This as before induces copious sweating. The sweat then evaporates and cools the body. The body temperature thus remains unchanged. One of the important functions of the skin is to prevent the rise of the body temperature above the normal *viz.* 98·6°F.

On a cold day, when the air temperature is low, heat is readily lost from the body surface; and the body temperature tends to sink. But this tendency is to a great extent counteracted by the following arrangement. The cold acts on the skin and leads to the contraction of its arteries. When the arteries contract they could hold only less blood. The greater part of the blood contained in them, for want of accommodation, is forced into the internal organs. Most of the warm blood is thus retained within the deep seated internal organs of the body wherefrom the heat cannot be

lost to the cold atmosphere. The body heat is thus protected from being easily lost and the body temperature does not fall. What would happen if the blood vessels of the skin did not constrict and if most of the blood in the skin was not sent into the internal organs? Then the heat in the warm blood in the skin would be readily lost into the cold atmosphere and the body temperature will certainly fall. But this, as mentioned already, is effectively prevented by the constriction of the arteries of the skin whereby most of the blood in it is diverted to and retained in the internal organs of the body. Thus the skin prevents the fall of the body temperature on a cold day.

If however, a person subjects himself to prolonged exposure to the cold of a cold atmosphere or of cold water when bathing in a tank or stream, the body temperature does tend to fall notwithstanding the action of the skin; for the blood is never still. It constantly streams through the body. The small quantity of blood that flows into the skin is cooled there and flows back to the heart; and more blood flows into the skin. This is again cooled. When this is repeated for a long time, clearly the body will be cooled and its temperature will tend to fall. Under such conditions the body protects itself by inducing shivering in various parts of the body. Shivering is but involuntary contraction of various muscles of the body. The muscular contraction generates sufficient heat to counterbalance the excessive loss of heat for a time.

Moreover, we all know that on a cold day we prefer to keep moving about or engage ourselves in some form of physical activity or other. Since every bodily movement is the result of muscular contraction we liberate more heat in our bodies on a cold day. This is but to make up for the greater loss of heat.

Also on a cold day, we all feel a keener appetite and take in more food. Food is after all the fuel which is burnt in the body for supplying it with the energy for its

activities and with the heat for keeping it warm. When there is greater loss of heat from the body, as on a cold day, it is necessary that more fuel must be burnt to keep it warm.

Again on a cold day, we prefer to put on warm clothing like flannel shirts. Wool being a bad conductor of heat checks the loss of heat from the body.

But more than these the skin is important in maintaining the body temperative constant; on a warm day it checks its rise and on a cold day, its fall.

In performing its heat-regulating function, the skin is, to a small extent, helped by the light covering of hair that it bears. Each hair is a slender strand of dead cells. It is planted in a minute tubular pit in the skin called the hair pit or hair-follicle. At the bottom of the pit is a tiny swelling to which the base of the hair is attached. This little swelling is provided with blood vessels and a nerve. From the surface of the swelling, fresh cells form and these are added to the base of the hair and make the hair grow. The elongation of the hair is thus caused by the addition of more cells at its base. The hair grows, not at its tip, but at the base. The little basal swelling has a supply of blood vessels and a nerve; but these blood vessels and the nerve stop there and do not extend into the hair strand. The cells of the hair strand have no blood supply and are therefore dead. It is on this account that when the hair is cut, no pain is experienced; but when the hair is pulled, there is pain for the pull causes a drag on the little swelling at the base of the hair and irritates the nerve that it contains.

Numerous as these hairs are, neverthless they may be erected. You will have noticed that when cold water is suddenly splashed on your body, the hairs stand on end. The erection of the hair is caused by the contraction of slender muscles in connection with each hair-pit. The

contracting muscle pulls at the hair-pit and thus erects the hair, the base of which is contained in it.

Hair is a good non-conductor of heat. You certainly prefer to wear a flannel shirt on a cold day, for it effectively retains the body heat. The function of the hairy covering is to act as a non-conductor of heat and thereby prevent the loss of heat into the surrounding atmosphere. It is thus intelligible why a polar bear which has got to face the Arctic cold is provided with dense long fur; and why animals in the tropics have neither such long nor dense fur. In man, the hairy covering is scanty. He makes up for this deficiency by means of clothes, houses, food, etc.

Opening into each hair-pit is one or two small oil-glands. These produce an oily substance which flows out to the surface of the skin through the opening of the hair-pit. The oily secretion serves to keep the hair glossy and the skin surface soft and supple.

Cleanliness of the Skin, Bathing, Kinds of baths.—As you have learnt already, the skin has many important functions to perform. It forms a natural cover for the body. It helps to maintain the body temperature constant. It helps in excreting part of the water absorbed by the digestive system. It absorbs oils and medicines applied to its surface. Having so many important works to do, the skin deserves to be well looked after and kept clean and healthy. What an amount of dust, stirred up by the street-traffic in towns, rests on the skin and mixes up with the oily secretion of the skin! The dirt so formed, if allowed to accumulate, may serve as a breeding ground for disease germs and may even tend to block up the sweat-pores and interfere with the free excretion of sweat. An easy and effective way of keepsng the skin clean is a daily bath in clean water. The bath will wash away the dust and oil and the salt left over by the evaporated sweat. The object of the bath being to cleanse the skin, it is clear that this purpose cannot be gained unless the water used is

clean. Tap water, clean well-water, or river water, when there is plenty of water in the river, is good for bathing purposes. Tanks, particularly the smaller ones, are unsuited for the purpose. Their banks are seldom maintained in a sanitary condition and the first rains of the year wash the dirt into the water. Moreover, all kinds of persons use the tank, some of whom, at least, suffer from festering sores or other skin diseases. Dirty clothes of all kinds of persons, even of those suffering from typhoid or cholera, are often carelessly washed in them. It is therefore quite reasonable to question the cleansing effect of a bath in such a tank. On the other hand there is every risk of contaminating oneself with disease germs when bathing in an unclean tank. Such tanks are unfortunately abundant. They are not only unfit for bathing purposes, but also serve as ideal breeding grounds for mosquitoes, those fatal disseminators of malaria. While it is not easy to drain them, every village and town could attend to the proper maintenance of their public bathing tanks. The tank may be annually cleaned of its water-weeds. Public opinion may be educated so as to prevent the dirtying of the sides of the tank and the bathing of persons suffering from skin diseases. The washing of dirty clothes by dhobies and the washing of cattle may also be prohibited.

For a person in robust health, a morning cold bath is the best suited. When taking the bath, a vigorous rub with a rough towel serves not only to scour off the loose scales of the skin along with the dust and dirt on its surface but also serves to improve the blood circulation in the skin and the muscles closely underlying it. The oily secretion of the skin together with the oil so often applied to it may be best removed with a good quality soap.

For aged persons in declining health, a tepid bath, in the evening, taken in a bathroom is more congenial. After taking a tepid bath it is necessary that one should not

expose oneself to a draught, else there is the danger of catching cold or even of developing the more serious lung-trouble.

Skin diseases, their causes and prevention.—One of the commonest skin diseases is itch. It it caused by a tiny parasitic animal called itch-mite. It burrows into the skin particularly between the fingers. As it burrows, it causes intense itching sensation. To allay the irritation, one scratches the surface of the skin with the fingers. In doing this, it may happen that some of the mites or their eggs stick to the finger tips and when some other part of the body, say the armpit, is rubbed with the fingers, the mites or their eggs get scattered over a fresh area of the skin and cause the disease there as well. In schools, contact between the hands of a pupil suffering from itch with the hands of those free from it, is sufficient to spread the disease to the latter. This necessitates the exclusion of pupils suffering from itch from attending school till they are thoroughly recovered.

Boils.—Boils are caused by a kind of germs. When a boil bursts, the boil germs are set free in the reddish white matter or pus that escapes from the boil. When this germ-carrying pus comes in accidental contact with the skin of another person or with some other part of the skin of the same person the germs penetrate into it through the pores and ducts of the sweat glands or through the openings of the hair-pits. Here it multiplies, destroying the tissues around. As the tissue-destruction progresses, the nerve endings in the skin are affected and there is pain When more and more of the tissues are destroyed, the pain increases and the germs which have enormously increased in number form a swelling or boil which may burst in time; but as time passes, more of the tissues are destroyed and considerable lancing pain is experienced. Instead of allowing it to develop further, it will be better to get it opened by a docter. This will

allow the escape of all the pus in the boil and immediate relief from the pain will be felt. The boil after it has burst or after it has been opened should be thoroughly cleansed with carbolic lotion, so also the hands and other parts of the skin which came in concact with the pus. Clothes soiled with the pus must be thoroughly cleansed by boiling or other means and the cloth used in wiping off the pus from the boil may be dipped in carbolic lotion or burnt off so that the boil germs in them may be destroyed and the chance of spreading the contagion through them may be prevented.

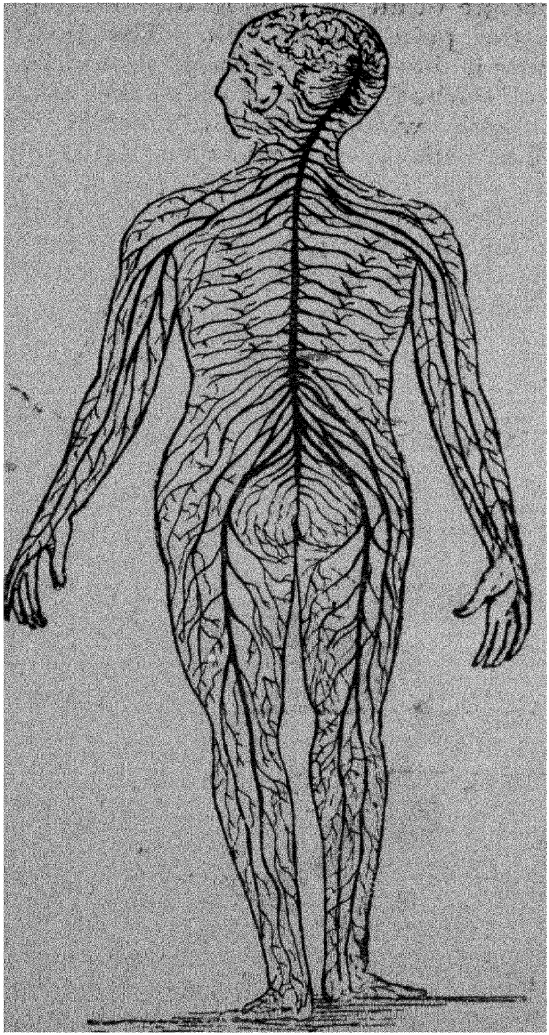


Fig. 49. **Brain, Spinal Cord and N**

CHAPTER X

THE NERVOUS SYSTEM

Just as the head of a Government directs and control the work of the State and just as his officers take his orders and carry them out, so also nervous system controls the manifold activities of the body. It sends out orders to the different organs. The organs carry out the orders. The nervous system is thus the governing system.

The Brain, Spinal cord and Nerves.—This system consists of three parts *viz.*, the brain which is enclosed within and protected by the cranium, the spinal cord which runs through the backbone, and the nerves which starting from the brain and spinal cord run to the different organs of the body.

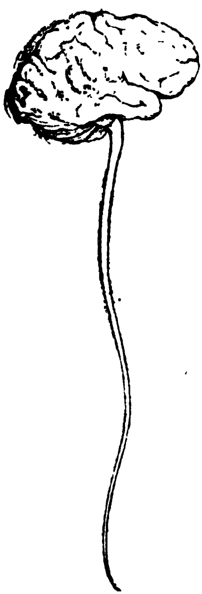


Fig. 41. Brain and Spinal Cord.

Nerve-cells and Nerves.—The nervous system is built up of a peculiar kind of tissue called nervous tissue. The nervous tissue is composed of nerve-cells and their fibres. The nerve-cell is a small mass of protoplasm with a nucleus. It has an irregular shape. From the margins of the cell grow out numerous branching protoplasmic filaments called nerve-fibres. The nerve-fibres are of different lengths. Some of them are long and the others short. The long fibres from several nerve-cells are bound together by connective tissue to form a white thread-like structure called the nerve. In an ordinary thread, the fibres composing it are twisted

together, but in a nerve the fibres composing it run parallel. The nerves are thus bundles of parallel nerve-fibres. A typical nerve as it runs outward from the spinal cord or brain is found to branch again and again like an artery. Each small branch nerve finally ends in some organ or other *e.g.*, skin, muscle, a gland etc.

The function of a nerve is to act as a communication cord between the various organs of the body on the one hand and the brain and the spinal cord on the other. For instance, when the foot is washed in cold water, immediately the cold sensation is conducted to the brain through the nerve ending in the skin of the foot. If the nerve happens to be cut, then no sensation will be felt. Or when a drop of honey is placed in the mouth, the sweet sensation is conducted to the brain through the nerve ending in the surface of the tongue. In the same manner sensations of sound, of smell, of vision, of pain in a muscle or in the stomach are conducted by nerves to the brain. The nerves thus act as sensation conductors.

Nerves also conduct orders, or messages from the brain and spinal cord to the various organs of the body. In the movement of bending the arm, a certain group of cells in the brain generates an order. This order is conducted to the biceps through a nerve. The biceps receives the order and then contracts. If the nerve to the biceps happens to be cut, then the biceps does not receive the order and the bending of the arm does not take place. Here the nerve acts as an order-conductor.

Nerves, we have already stated, are but bundles of nerve-fibres. The sensation or order conducted by a nerve travels actually through the numerous nerve-fibres composing it. It has been found that certain nerve fibers conduct only sensation to the brain and that these are quite distinct from other nerve-fibres which conduct only orders from the brain to an organ. A single nerve-fibre can thus do only one function. It can conduct either a sensation to

the brain or it can conduct an order from the brain to an organ. A single nerve-fibre never does both. It cannot convey a sensation to the brain at one moment and an order from the brain to an organ at another.

The orders or sensations conducted through a nerve-fibre though they do not travel through it with the speed of electricity through a copper wire nor even of sound through the air, yet travel at a very great speed indeed viz. about 472 feet per second or 70 miles an hour.

Nerve-fibres are not confined to the nerves alone. They are present in the brain and the spinal cord as well. The distinguishing feature of these organs is not, however, the presence of nerve-fibres in them but the presence of an enormous number of nerve cells. There are certain parts of the brain and the spinal cord which are almost entirely composed of nerve-cells; though there are also other parts which are practically all nerve-fibres. These different parts are easily distinguishable; for the parts where the nerve cells are concentrated are gray in colour and the others white. These are respectively called the gray matter and the white matter.

The nerve-cells are the most essential parts of the nervous system. It is they that are capable of generating an order and sending it to an organ. There are many muscles in each arm and with their help we perform numerous actions, write a letter, or wield a tennis bat, or lift the food to the mouth. There is a particular group of nerve-cells in the brain which generates orders to produce the contraction of the different muscles of the arm. If, owing to an injury to the brain, this particular group of cells is destroyed, then the arm is paralysed though the muscles or their nerves have sustained no injury. Every organ in the body, with the exception of the heart, normally works only as a result of orders generated and sent to it from some particular group of nerve-cells or other.

The nerve-cells have another important function. Different kinds of sensations are continuously carried to the brain from the eye, the ear, the nose, the tongue, the skin etc. These sensations are received by different groups of nerve cells and they enable us to recognise these different sensations. There is a bird singing on the tree outside our room. The sound reaches the ear and conveyed to the brain. Then we become aware of the melody outside. If the group of nerve cells in the brain, concerned with hearing is injured, the person becomes deaf though the ear and its nerve may remain uninjured. The nerve-cells enable us to receive and recognise sensations.

The brain.—It is the supreme possession of man. He owes his supremacy over the rest of the Animal Kingdom to his brain. The individual greatness of the genius is

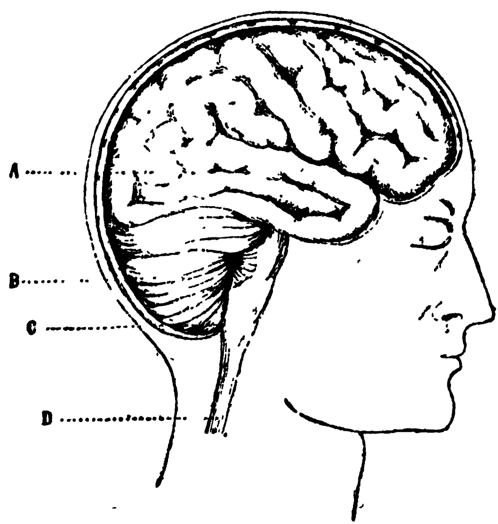


Fig. 42. A. Large brain. B. Little brain. C. Skull. D. Spinal Cord.

again due to the quality of his brain. It weighs on an average about 49 oz in men and 45 oz in women. The

principal parts of the brain are three, *viz.*, the large brain, or the Cerebrum, the little brain or the Cerebellum and the Spinal Bulb.

The large brain or the Cerebrum.—This is the largest part of the human brain; in fact, it is many times larger than the rest of the brain. It is divided into two halves, a right and a left by median groove. The interior of the cerebrum is white in colour and is composed mostly of nerve-fibres. Its surface is gray in colour. This constitutes the gray matter of the cerebrum. Herein is a great concentration of nerve-cells. It has been estimated that there are more than a thousand million nerve-cells in the gray matter of the cerebrum. The surface of the large brain is not smooth; but is folded into numerous ridges and furrows. These undulations greatly increase the surface area.

The large brain is the seat of a great many functions. It is the seat of consciousness. We are aware of what is happening around us only through its help. In deep sleep this part of the cerebrum is inactive and that is why one in profound sleep does not know what takes place around him. It also contains many distinct groups of cells each group concerned with a single function *e.g.*, one group is concerned with speech. If for any reason this cell group is injured, the person loses his ability to speak though his tongue and vocal cards may remain in perfect condition. A definite group of cells concerned with a definite function is called a centre. The cerebrum contains not only the speech centre but also the centres of vision, of smell, of taste and of hearing. It also contains the centre which causes voluntary bodily movements like walking, writing, etc. It is interesting in this connection to remember that the centre controlling the voluntary movement of the right half of the body is located in the left half of the cerebrum, and the centre controlling the similar movement of the left half of the body is placed in the right half of the cerebrum. Often, persons of advanced age suffer from paralysis of

one side of the body. This is caused by an injury to the centre of voluntary movement. When the right side is paralysed, it is caused by an injury to the centre in the left side of the cerebrum; and when the left side is paralysed it is due to an injury to the centre in the right side. The extent of the paralysis will depend upon the extent of the injury to the centre. When the injury to the centre is extensive, the paralysis is more complete. The cerebrum is also the seat of memory. It is with its help that we remember faces, incidents, sceneries, pictures, and music. Years may pass but memory is vivid as long as the cerebrum is sound.

The little brain or Cerebellum.—Every voluntary movement like walking, riding a cycle etc, is, we have stated, brought about by the centre of voluntary movement in the cerebrum. But in the performance of all these movements the cerebrum is helped in its work by the cerebellum; for when the latter is diseased, the movements though performed are carried out in a clumsy manner. The man with a diseased or injured cerebellum, though able to walk, yet walks only with an irregular and staggering gait. This is due to the fact that the numerous muscles concerned in the walking movement do not work in perfect harmony *i.e.*, they do not contract or relax at the correct time and to the correct extents. Since the lack of harmony and the consequent irregularity in the movement is seen only when the cerebellum is injured or diseased, it is inferred that it helps to make the muscles work harmoniously in any voluntary movement. You must have all seen how the gait of a drunken man is stumbling and unsteady and how he reels and zigzags instead of keeping straight. This is due to the action of the alcohol temporarily poisoning the cerebellum. The function of the cerebellum is to help the cerebrum so as to bring about the harmonious working of the muscles in any voluntary movement.

The spinal bulb or medulla oblongata.—It is the part of the brain which is in connection with the upper end of the spinal cord. It serves to connect the spinal cord on the one hand with the rest of the brain on the other. All messages from the cerebrum or other parts of the brain to the organs in the trunk and limbs pass through the spinal bulb. So also all sensations from the organs of the trunk and limbs pass through the spinal bulb to reach the cerebrum or other parts of the brain. The spinal bulb therefore serves as a great highway for conducting messages from the brain to the trunk and limbs and for sensation from the latter to the former.

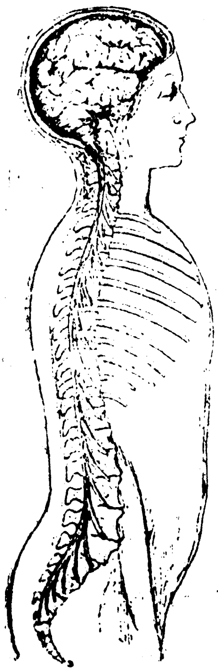


Fig. 43. Brain and Spinal Cord.

It is also the seat of the centre which controls breathing and the centres which hasten or slow the beating of the heart.

The Spinal Cord is a stout cord of nervous tissue with a tapering lower end. It runs through the vertebral column. From between every pair of the vertebræ starts a pair of spinal nerves. These connect the different organs of the trunk and limbs with the spinal cord and serve to conduct sensations from the skin and other organs of the trunk and limbs to the spinal cord. Through the spinal cord these sensations travel up to reach the brain. Also messages from the brain to the muscles and other organs of the trunk and limbs pass down from the brain through the spinal cord first. They are then despatched through the spinal nerves. The spinal cord

enables the exchange of sensations and messages between the organs of the trunk and limbs, and the brain.

Reflex Action.—Further, the spinal cord enables the performance of many reflex actions. A man accidentally falls down from a building and severely hurts his back breaking his spinal cord. In the part of the body, below the zone of the injury, he has no feeling and cannot effect any voluntary movement of its muscles. If, however, the foot is pinched, it is immediately withdrawn. He does not feel the pinching sensation for it cannot travel up through the injured cord; nor can he withdraw the leg of his own accord as no messages from his brain can travel down to the leg. The withdrawal of the leg is clearly done without his knowledge or his will. How is it then done? The pinching sensation is carried up by the nerve from the skin of the leg to the lower part of the spinal cord below the injury. The cells of the cord receive the sensation and produce a suitable message or order which is sent to the muscles of the particular leg through the nerves. The muscles receive the message and contract, so that the leg is withdrawn. The withdrawal of the leg takes place without his will. It is therefore an involuntary action. Such involuntary actions are called reflex actions. Many such involuntary actions take place every day in our system.

A person makes a quick movement at another as though to strike him on the eye. Immediately the eyelids of the latter close. Here the blinking of the eyelids is not deliberately done. It is not as a result of his desire that the eyelids close. The closing of the eyelids is involuntarily done. Try this experiment on your class fellow.

A hungry man sees a plate of food. His mouth immediately waters. The flow of saliva takes place involuntarily. In fact under such conditions he cannot even prevent the flow of saliva. Have not you felt the same?

Tickle with a pencil or stick the sole of the foot of your class fellow without previously telling him about it. Notice how quickly he lifts up the tickled leg.

A person touches a hot body without knowing that it is hot. At once the hand is withdrawn.

Cold water is splashed on the bare body. The hairs stand on end. The erection of the hairs is always involuntary. The muscles in connection with the hair pit are involuntary muscles.

When taking food, a bit of food takes the wrong path and passes into the wind-pipe. At once there is violent coughing to expel the irritating particle of food.

When the sole of the foot is tickled, the reflex action is brought about with the help of the spinal cord. The sensation from the sole of the foot first travels to the spinal cord and the latter sends out a message to the muscles of the leg. In the case of the closing of the eyelids, the image of the uplifted hand falls on the eye which conveys the sensation to the brain. The brain sends out a message to the muscles of the eyelids and then the eyelids are closed. Here the reflex action is effected with the help of the brain. This is so in the case of the flow of saliva at the sight or the smell of food. Reflex actions may be carried out with the help of the spinal cord or of the brain; but in every case it takes place without affecting the will and therefore reflex actions are involuntary actions.

Mental fatigue.—A muscle which has vigorously contracted for some time passes into a state of fatigue and is unable to contract any further. Similarly every organ of the body which works for a certain period gets fatigued. No organ can work continuously for fatigue sets in after a time. Even the heart which appears to work incessantly throughout life takes a short rest after every contraction. Work, fatigue and rest form a natural and normal cycle. During the period of work, every organ loses both material and energy. During the period of rest, it regains what it

has lost. When this is done, the organ is ready for more work.

Just in the same way the brain is also subject to fatigue. Just before your examination, when you begin to work hard at your lessons, you may find that after about two hours of hard study your brain is unable to absorb any more of the printed matter in your book. Your eyes still run over the lines but the meaning of what you have read has not left any impression. Any more time spent in reading is wasted for the brain is fatigued. It demands rest before any more useful study can be attempted.

There is a clerk in an office. His work is to add up columns of figures. When he started, he was fresh to the work and the additions were done correctly. After a time mental fatigue sets in. He goes on adding; but errors begin to appear and as he continues at it, more and more errors follow. The increasing number of errors is an accurate index of his increasing mental fatigue.

How do we get over mental fatigue? Sleep is Nature's own remedy. You go to a quiet room, put out the light and stretch yourselves in the bed. Consciousness vanishes and the fatigued centres of the brain take rest. After about 6 to 8 hours of sleep at night, you feel thoroughly refreshed and get up ready for another spell of hard work. That is why early in the morning you are able to learn your lessons without effort and morning time is the best time for mental work.

While morning time is the best for mental work, the time immediately following a hearty meal is the worst. Why? Every organ when it does work requires more blood, for more blood means more oxygen and more food-materials. After a meal, the stomach begins to work. Its blood vessels dilate so that it may have more blood to produce an adequate quantity of gastric juice to carry on digestion. If, at this time, you begin your study, your brain begins to work and for its work it requires more blood. Now, brain

is the supreme master of the body. As soon as it requires more blood, it reduces the blood supply to all other organs of the body by bringing about a slight constriction of their arteries. The blood supply to the stomach is thus curtailed. This leads to insufficient secretion of the gastric juice which in its turn may lead to indigestion. The incompletely digested food ferments or putrifies in the alimentary canal due to the action of intestinal bacteria and liberates poisonous substances. These poisons when absorbed into the blood cause headache which is mostly a cry for pure blood. To take an hour of rest after a heavy meal is a wholesome habit which you boys should not forget to cultivate.

CHAPTER XI

THE SENSE ORGANS

It does not require much to be said to realise the great importance of the sense organs. Imagine a man, born blind and deaf and with an insensitive skin. He has never seen anything, never heard anything, and never felt anything. The result is he knows nothing. All knowledge and all experience are first got through the different senses.

The chief sense organs are the eyes, the ears, the skin, the tongue and the nose.

The Eyes.—Vision is the highest sense and the eyes form the most important sense organs. Their importance has received such age-long recognition that in many languages, terms of high endearment refer to them.

Each eye is round like a ball and is lodged within a bony cup of the cranium. The wall of the eye-ball is white and opaque except in front where for about a sixth of its surface area, it is colourless and transparent. The eye-ball contains a cavity which is divided into two unequal rooms, a small one in front and a large one behind. The two rooms are separated by a lens which forms a partition wall between them. The lens is transparent and like a magnifying glass it is biconvex. The small room in front of the lens is filled with a thin watery liquid and the large room behind by a thick jelly-like material. Both the watery liquid and the jelly-like material are colourless and transparent. In the front room or chamber, just in front of the lens is a coloured opaque curtain with a central opening. The curtain is called the *iris* and the opening the *pupil*. Look at the eye of one of your class fellows or at your own in a mirror. Note the white of the eye and the transparent cornea. Also note the *iris* with its dark central spot, the pupil. It is through the pupil that light is admitted

into the inner part of the eye and just as with a curtain, we can adjust the amount of light entering a room-so also with the curtain of the iris, the amount of light admitted into the inner parts of the eye is adjusted The adjustment is effected by means of muscles in the iris. The muscles can either widen the pupil and so allow more light to enter or narrow it and so allow only less light. In bright sunlight, if we walk out, we find that there is all around more light than what is necessary for distinct vision, then the pupil becomes narrow and shuts off the excess of light. At night when there is only the feeble moonlight or the feebler starlight, there is not enough light for distinct vision. Then the pupil widens to admit more light, so that better vision may be possible. This change in the size of the pupil may be

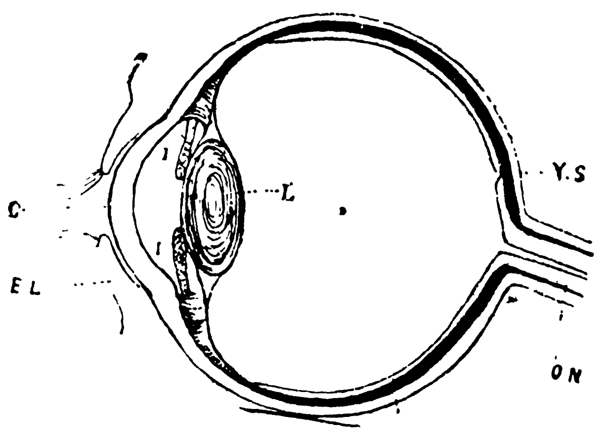


Fig. 44. **Section through the Eye** C., Cornea, E.L., Eyelid. L., Lens. O.N., Optic nerve. I.I., Iris, in front of lens. Y.S., Spot of clearest vision or yellow spot.

very clearly seen in the cat's eye. If you examine the cat's eye during the day you will notice that the pupil is reduced to a mere slit in the iris. In the night it is a very wide circular aperture. A similar alteration in the width of the pupil

may also be seen in the human pupil but it requires careful scrutiny to be noticed. The iris may justly be called the light adjusting curtain of the eye. It is usually brown or black among the Indians and according to its colour we call an eye black or brown.

The light passing through the pupil enters the large back room of the eye ball. It is, as we have mentioned before, filled with a clear transparent jelly. The inner surface of this room is lined with a delicate sensory membrane, called the *retina*. Light from outside objects passing through the pupil falls on the retina and leaves an image on it. It is then that we see the object; for there is a nerve connecting the retina with the brain which conveys the sensation to the latter. To bring the image of the object to a clear focus on the retina, a suitable lens is necessary and such a lens we find placed behind the iris. Just as the camera lens brings to a distinct focus on the sensitive plate the image of the object photographed, so does the human lens focus the image of an object on the retina. Were the lens absent, the image formed on the retina would be blurred and indistinct.

These different parts of the eye may be readily made out in a sheep's eye got from the butcher. The eye may be cut into two along a median line running from front to back with the help of a razor. Only the watery liquid in the front chamber of the eye will run out as the eye is cut.

Each eye-ball can be rolled about in its bony cup by means of six muscles and the two eyes are moved in such a manner that both of them are, except in squint-eyed persons, directed towards the same object looked at. The front surface of the eye-ball is very sensitive. You know how even a speck of dust causes intense irritation. To protect the eye in front are two movable eyelids fringed with hair or eye lashes. The two eye-lids wink every few seconds, and as they pass over the surface of the eye-ball, wash its surface clear with the help of a light amount of the

watery secretion of the tear glands. Each eye has its own tear gland. It is placed between the eye-ball and its bony cup at the outer border of the eye *i.e.,* the border of the eye

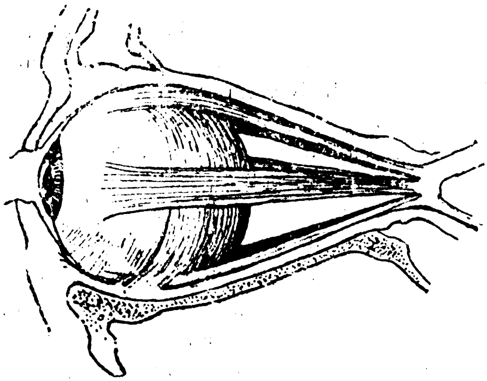


Fig. 45. **Showing the eye-ball in its bony cup with the muscles which roll it.**

near the *pinna.* It pours its secretion into the very narrow interspace between the eye-ball and the eyelids. The tear secretion is produced ordinarily in such small quantities that it escapes notice; but under conditions of intense grief or as when irritated by the vapours of a crushed onion it is copiously produced and flows out as tears. Most of the tears may run down the cheeks; but a small part may flow down into the nasal cavity through two small openings placed on the eyelids near the inner border of the eye *i.e.,* the border of the eye near the nose. These tiny pores may be readily seen. Keeping a mirror in front gently, pull down the lower eyelid. At the margin of the eyelid near the side of the nose do you note a small aperture? The opening in the upper eyelid is placed immediately above this. It is because of this connection between the eye and the nose that one who weeps sneezes at the same time.

The tears, besides helping to wash the eye-surface and keep it scrupulously clean and moist, have another very

important function, that of destroying most kinds of injurious disease germs that may alight on the eye surface. For this purpose the tear secretion contains a powerful germ-destroying substance called lysozyme.

The tear glands and the eyelids have very important works to do; but the eyebrows which are placed a little above the eyes, though they have no very important function to perform, however, contribute a little to eye-comfort. While engaged in violent physical exertion and when the sweat pours down the forehead, the eyebrows prevent the sweat from running down into the eye and divert it so that it flows off to the side of the face.

More precious than jewels the eyes demand the greatest care. Nowadays owing to the constant need for reading printed matter in books and papers the eyes are subject to very great strain; but the eye-strain may be greatly lessened if attention is paid to proper lighting of the reading matter. Reading in the fading light of the evening is one of the potent causes of eye-strain. At the same time over brilliant light is also fatiguing to the eye. Light which is not over-bright but bright enough to enable one to see printed matter clearly and without effort is the best suited for reading purposes. The lamp may also be so adjusted that the light may illuminate the book or other reading matter without falling directly upon the eyes. Where the lamp does not admit of any such adjustment, an eyeshade may be worn to cut off the direct light from the lamp. Recently cinema theatres have brought in one more factor of eye-strain particularly to those who occupy the cheap front seats where the flickering effect of the moving picture is great.

Two of the commonest eye defects go by the names of short sight and long sight. In short sight a person has clear and distinct vision of objects nearby; but objects at a distance are indistinct to him. A school boy having short sight can read his books with ease; but cannot make out what is written on the board. This kind of error in

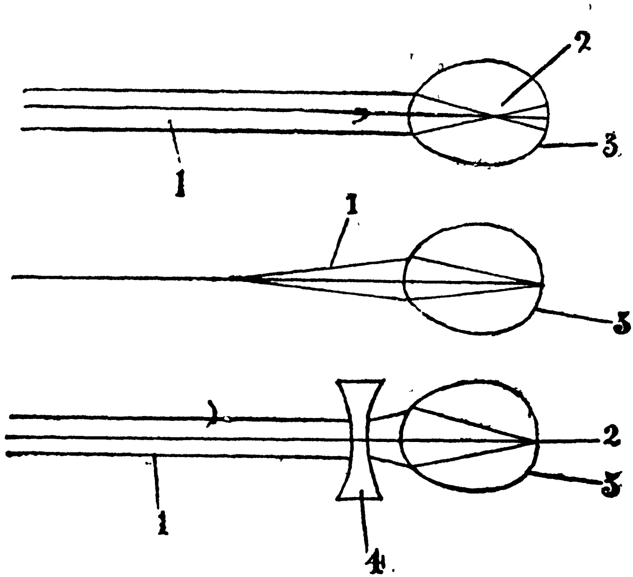


Fig. 46. **Diagrams to illustrate Short Sight.**

I. 1-a pencil of light from a distant object, brought to a focus at 2 in front of the retina 3.

II. 2 a light from a near object at 1 brought to a focus on the retina 3.

III. 1-a pencil of light from a distant object, as in I, brought to a focus at 2, on the retina 3, due to the help of the biconcave lens 4.

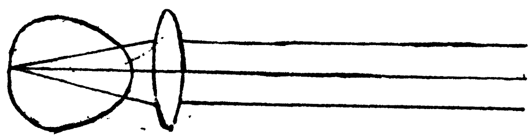
vision is caused by defective eye-structure. The eye-ball from front to back is much too long in short sight, so that the image of an object is brought to a focus in front of the retina. The image which then falls on the retina is blurred and indistinct. The defect can be corrected by the use of spectacles with bi-concave lenses.

On the other hand, a boy suffering from long sight can easily read anything on the blackboard but finds it straining to read from a book unless it is held at arm's length. Here the defect is caused by the fact that the eye-ball from front back is much too short so that the image of a near

object can be brought to a focus only behind the retina. The image that actually falls on the retina is indistinct. This error in vision may be corrected by the use of spectacles with suitable biconvex lenses.

Some boys often, after reading their lessons for a time, are attacked with a bad headache and even watering of the eyes. This may be due to eyestrain, consequent upon the

I



II

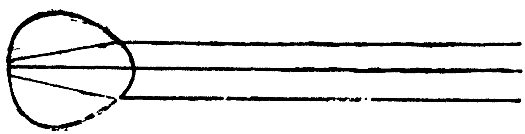


Fig. 47. Diagrams to illustrate Long Sight.

I. Light from an object brought to a focus on the retina due to the help of the biconvex lens.
II. Light from an object brought to a focus beyond the retina.

boy suffering from long sight. Such headaches may be immediately relieved by the use of spectacles to correct the long sight.

The eyes being the highest sense organs, any defect in them as soon as noticed should receive immediate attention from an eye-doctor. It is much more easy to correct a defect or arrest its progress in its initial stages than later.

The Organs of Hearing.—*The Ears*—Each ear consists not merely of what is popularly known as the ear *viz.*, the pinna which projects on each side of the head but also of other parts which are not visible externally but are lodged deep in the side of the skull.

The entire organ of hearing is divisible into three parts which are called external ear, middle ear and internal ear.

The external ear is itself composed of two parts. Firstly,

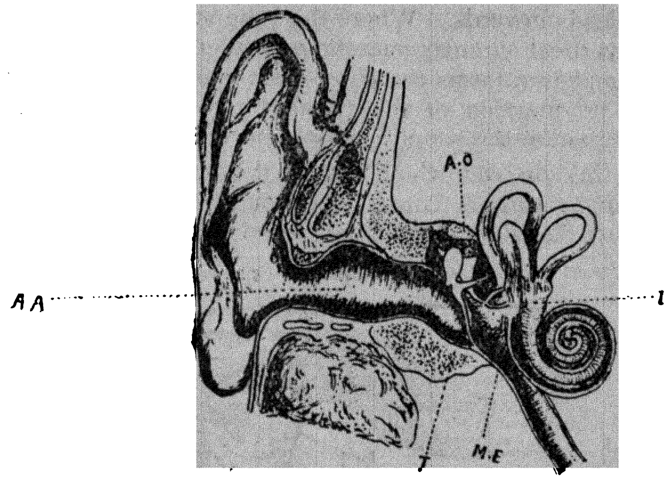


Fig. 48. Ear-apparatus

A. A. Tubular part of external ear; A. O. Chain of bones of middle ear; T. Tympanum; M.E. Middle ear; I.E. Internal ear.

the externally projecting pinna which consists of an irregularly folded plate of skin covered cartilage. It has roughly the shape of a mussel shell. The function of the pinna is to act as a sort of funnel or ear-trumpet to collect the waves of sound. In animals like the cow, the goat &c., the pinna is large and freely movable, there being well developed muscles in connection with it. The large pinna of these animals not only helps to gather the sound waves, but being movable, helps them to locate accurately the direction from which the sound is proceeding. You must have seen how the draught animals like the bulls, the horse etc., prick up their ears when they are spoken to by their driver. In man the pinna is not movable; the muscles, in connection with them though present, are re-

duced and have fallen out of use. However, as you perhaps have seen, there are exceptional individuals who can slightly move their pinna.

Secondly, the external ear consists of a short blind tube which leads inwards. Where the tube stops, it is closed by a vertical circular membrane called the tympanum. The tympanum forms the outer-most part of the middle ear. The function of the tubular part is to conduct to the tympanum the sound waves collected by the pinna.

The middle ear which forms the second part of the organ of hearing is constructed roughly like a drum. It is a short, air-filled, bony tube closed at the two opposite

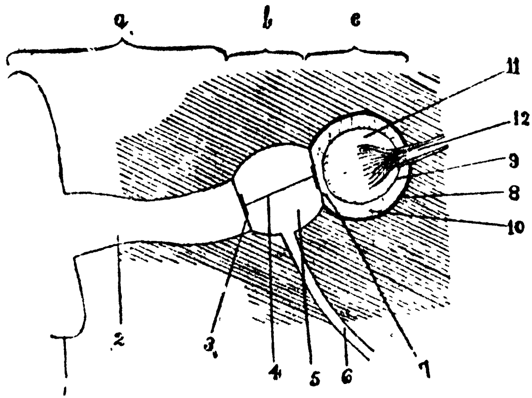


Fig. 49. **Diagram of Ear-apparatus**

a, external ear ; b. middle ear ; c. internal ear ; 1. pinna ; 2. tubular part of external ear ; 3. tympanum ; 4. Chain of bones of middle ear ; 5. air-filled cavity of middle ear ; 6 tubular passage connecting middle ear with throat. 7. oval membrane ; 8. bony chamber of internal ear ; 9. membranous chamber of internal ear ; 10. liquid filling interspace between the bony and the membranous chambers ; 11. liquid filling membranous chamber ; 12. nerve of hearing.

sides by means of two membranes. The outer of these is referred to already, it is the tympanum. The inner is a smaller membrane, oval in outline. This closes an oval window-like aperture in the bony wall of the internal

ear. Running from the tympanum to the oval membrane is a short chain of tiny bones, the tiniest in the entire human system. When the sound vibrations travelling through the tubular part of the external ear strike against the tympanum, it is made to vibrate. Immediately the vibrations of the tympanum are conducted by the chain of bones to the oval membrane. This transmits the vibrations in its turn to the internal ear.

The cavity of the middle ear is connected to the throat by a narrow tubular passage which serves to keep the pressure internal and external to the tympanum equal.

The third part of the organ of hearing is the internal ear. It consists of a bony chamber with intricate spiral and semi-circular passages. The bony chamber encloses within it another chamber of identical design but slightly smaller, so that the latter rests snugly within the former. The inner chamber is not of bone but of thin transparent membrane and it is filled with a watery liquid. The narrow interspace between the bony chamber and the membranous chamber is also filled with the same kind of liquid. Spread out in the liquid in the cavity of the membranous chamber is one end of the nerve of hearing. On the wall of the bony chamber, facing the middle ear is the oval window closed by the oval membrane referred to already. This membrane is on its outer side in contact with the chain of bones and on its inner side with the liquid filling the interspace between the bony and the membranous chambers. When the oval membrane receives the vibrations through the chain of bones, it readily transmits them to the liquid with which it is in contact. The liquid in its turn transmits them to the wall of the membranous chamber which next transmits them to the liquid within, from which the nerve of hearing receives them. The nerve finally conducts the sensation to the brain. It is then that we hear the sound. While it takes much time to speak of the parts through which the sound vibrations travel, it takes actually

only a fraction of a second for one to hear a sound produced nearby.

The ears are important sense organs. Without them how poor our lives would have been! How could we converse with our fellow beings or enjoy the delights of music. The ears deserve proper care. Fortunately the delicate parts of the ear are duly sheltered in the bony wall of the skull. The delicate tympanum is, as we have seen, not flesh with the surface of the face where it may be easily injured but at the end of a tube. The tubular part of the external ear may appear at first sight to offer a tempting shelter for small insects; but as a matter of fact insects very seldom get into it. The reason is that the sides of the tube produce a brown waxy material which is repulsive to insects. Serving such a useful purpose, the wax need not be scooped out from time to time. Any excess of the material will naturally appear at the orifice of the external ear and may be wiped off with a towel while bathing. The habit of using a metal spoon is inadvisable as it may strike against the delicate tympanum causing severe pain or even injury; and injury to the tympanum is the common cause of defective hearing. Little children must be guarded against the habit of forcing small seeds, stones, etc., into the ear.

The Sense Organs of the Skin.—You have already learnt about some of the important functions of the skin. There is one other important function of the skin and that is the function of the skin as a sense organ.

You know how by dipping your hand in a vessel of water you can find out whether it is warm or cold. It is the skin that comes in contact with the water and it is with the help of the skin that you are able to perceive the sensation of heat or cold.

Placed in the dermis, immediately below the epidermis are numerous little oval bodies and each of which is in connection with a slender nerve. They are minute, and though they look alike more or less, they do different

functions. Some of them are sensitive to warmth. When the finger touches a warm body, the heat passes through the epidermis and these sense bodies are affected. The *sensation* of warmth is then conducted by the nerves in connection with them to the brain. These sense bodies which are sensitive to heat may be called heat sense bodies. There are others which are sensitive to cold. They may be called the cold sense bodies. There are still others which are sensitive to touch or pressure and these may be called the touch or pressure sense bodies. The different kinds of sense bodies are scattered throughout the skin but not uniformly. In some parts there are more of them ; and in others less. Where there are numerous sense bodies in a small area, the skin is very sensitive, and where there are only a few, the skin is only slightly or much less sensitive.

Take a divider and a foot rule. Perform the following simple experiment on your own body or on that of a class-mate of yours. Ask him to keep his eyes closed or blind-fold him. Now set the points of the divider $\frac{1}{12}$th of an inch apart. Then gently touch the tip of the nose and then the tip of the forefinger with the points of the divider. Ask him to tell you, whether he feels the touch of one point or two points. If the experiment is done carefully, you will be surprised to hear that he feels only one point on the nosetip but two on the finger. This shows that the ball of the forefinger is more sensitive to touch than the tip of the nose. To recognise the points of the divider as two, it has to be kept :—

1/12th of an inch apart on the tip of the finger,
1/4th of an inch apart on the tips of the nose ,
1/2 an inch apart on the palm of the hand, and
1 inch apart on the back of the body.

Whenever you wish to feel the nature of any surface, say the smoothness of a newly made table, you invariably run the tip of your fingers on its surface. Why? It is

because the finger-tips are particularly sensitive to touch or pressure, there being a very rich supply in it of the touch sense bodies.

Besides the above mentioned sensations felt by the skin, we feel with its help the pain sense as well. Pinch your skin between the fingers, immediately you feel the pain. Thus with the help of the skin we experience the heat sense, the cold sense, the touch sense and the pain sense. These different senses are felt with the help of the different sense bodies. With the help of the heat sense bodies, heat alone is felt and not touch ; and with the help of the touch sense bodies, touch alone is felt and not cold or heat. Each kind of sense body is sensitive to only one kind of sensation and to no other.

It is usual to talk about the five senses. Now when you have studied about the sense organs of the skin you will readily realize that there are really more.

The Organ of Taste.—The tongue is the organ with which we appreciate the taste of our food, and of other materials. Its surface is sensitive to only four different tastes—the sweet, the bitter, the sour and the saltish tastes. The tip of the tongue is particularly sensitive to the sweet taste and the back part to the bitter taste. If you had ever taken a dose quinine, you would have felt an extremely bitter taste clinging for hours to the back part of the tongue. The sour taste is best felt with the upper surface and the two sides of the tongue. The saltish taste, however, may be felt equally well on any part of the upper surface.

If you examine the surface of your tongue in a mirror, you will notice that its surface is rough due to the presence of numerous slightly projecting rounded bodies, each one of which looks like a small unopened mushroom. Between these bodies are extremely narrow grooves, by the sides of which are placed the numerous little organs sensitive to taste called taste buds. Each taste bud is of course in

connection with a slender nerve. These taste buds are sensitive to the taste of substances which can undergo solution. In other words an insoluble substance is tasteless. We perceive the sweet taste of a lump of sugar placed on the tongue only as it begins to dissolve in the saliva. If you place a drop of sugar solution on the tip of the tongue, you immediately feel the sweet taste; but if you carefully dry the tip of the tongue with a towel and then touch the tip with a little lump of sugar, no sweet taste is felt, till the tip of the tongue becomes again moist.

An insoluble substance has no taste. We have never felt the taste of the glass tumbler, or the china cup. Oils are also insoluble. Why then do you feel an aversion to take castor oil or cod liver oil? These oils have no taste but do have an unpleasant smell. When these oils are taken, their unpleasant smell travels to the nose producing the nausea. Ghee on other hand, though tasteless, is well relished. It is because of its pleasing odour.

It is thus really a mistake to talk of the bad taste of codliver oil or the good taste of ghee. Both are tasteless: the former has an unpleasant smell while the latter has a pleasing one. In the same manner, neither a slice of potato nor a slice of onion have any appreciable difference in taste; but yet we can immediately tell the difference, the moment they are placed in the mouth. The pungent smell of the onion then travels into the nasal cavity through the throat. If you are first blind-folded, and then while you hold the breath, a slice of onion and a slice of potato are placed in your mouth one after the other, you will not be able to say which is which. However, the moment you begin to breathe you can easily identify them.

The enjoyment of the food is not merely due to the pleasant taste but also to its pleasant smell or flavour. The edible fruits, those morsels of sun-cooked food, are universally enjoyed not only because of their pleasing taste but also of their delightful aroma.

The Organ of Smell.—The sense of smell is perceived with the help of the membrane lining each nasal cavity; but it is not the entire membrane that is sensitive to smell. The sensitive area is confined to a small patch of the membrane one quarter of a square inch in area. This is yellow in colour and is placed at the top of each nasal cavity. That is why when you wish to smell a flower, you sniff up the air, so that it may reach the upper part of the nasal cavity where alone the area sensitive to smell is located.

The sensitive area occupies only one quarter of a square inch in man; but in the dog it occupies about ten square inches. It is no wonder then that in the dog the sense of smell is so acute as to enable a bloodhound to track down a criminal after smelling his garment once.

Just as a substance can be tasted only if it can pass into a state of solution so a substance can be smelt only if it can pass into the gaseous state. Non-volatile substances have no smell.

The sense of smell is easily fatigued. When a villager visiting a city comes across an open drain for the first time he feels the foul smell keenly; but if he is compelled to live in a house nearby for some months, he may very soon fail to notice the smell. He will notice it again only when for any reason the evil smell happens to become excessive. In the same manner in a perfumed atmosphere like that of a marriage pandal, we may note the odour on entering it but after sitting there for half an hour we fail to notice it any further.

CHAPTER XII

FIRST AID TO THE INJURED

"A stitch in time saves nine" is a wise old saying and it holds true in the case of accidents. Accidents happen in the school, in our houses, or the play-ground, etc. A boy cuts his finger; another gets up a tree, falls down and breaks a bone; the child in the house goes near the lighted lamp and its clothes catch fire; a boy who has not practised swimming gets drowned while bathing; and so on. When accidents like these happen, if you do the right thing immediately, serious consequences may be averted. A stitch in time may save nine. But, in very many cases, the right thing is not done, due to ignorance. It is most necessary that everyone should possess some knowledge ot what to do in the case of accidents. In this little book I can refer only to a few common accidents and to indicate briefly the sort of first aid that should be rendered in each case. In order that you may be able to render first aid successfully you must *practise* the methods of first aid for some days, under the guidance and supervision of a qualified medical man.

Burns and Scalds.—Burns are common accidents in our houses—children going near the oven or the lighted lamp and their clothes catching fire. Many lives of children have been lost due to the people in the house not knowing what to do. If the clothes of a child catch fire, the first thing to do is to smother the fire. How best to do it? If water is ready at hand the thing is easily done. When water is not readily available people get perplexed. They run out to fetch water and by the time water is brought, the child is all burnt. Remember that not a second should be lost in smothering the fire. You know that nothing will burn unless it is supplied with air. How

do you put out the flame of the spirit-lamp? You put the cap on it and thus cut short the supply of air. The flames on the child's burning clothes are easily put out by covering up the body of the child (the face must not be covered) with a thick blanket and rolling the child on the ground, beating the blanket all the time. If a blanket cannot be had, any other thick stuff as, for instance, a coat will do just as well. Even a quantity of sand or earth thrown at the fire will smother it. After the fire has been put out, the next thing to do is to remove the clothing from the child. This must be done with great care. The burnt part of the skin should be protected from

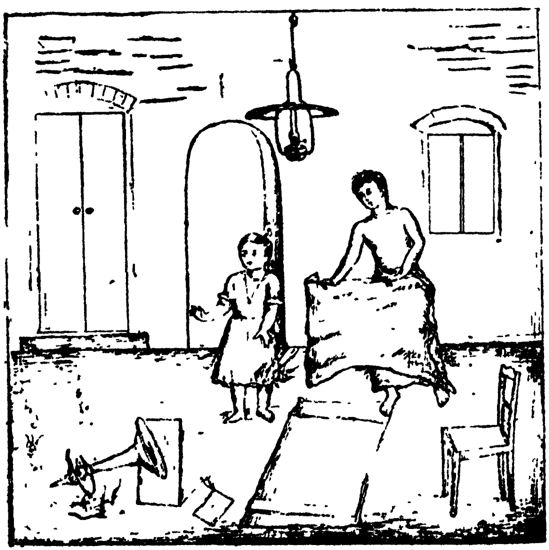


Fig. 50. A child's clothes on fire.

air and dust, as otherwise, poisonous germs present in the air and dust would get into the blistered skin. For this purpose a piece of linen soaked in cocoanut oil should be carefully applied over the burnt part. In the meantime a

doctor should be called in to find out the extent of the injury and if anything further is needed.

When a part of the body gets scalded by boiling oil or water, a piece of clean cloth soaked in cocoanut oil should be applied on the scalded part. In the case of severe scalds, a doctor should be consulted.

Bites, Stings, etc.—*The snake bite.*—Deaths from snake bites occur frequently. When a poisonous snake bites a person, say, on a limb, it causes a wound by means of its sharp poison fangs and injects a quantity of venom into it. If nothing is done immediately, the poison mixes with the blood and is very soon carried to the heart by the veins. The only method by which this could be prevented is by applying pressure on the veins by tying two or three tight ligatures, one above the other, round the limb above the wound. The ligatures may be tied with a cord or with a piece of cloth. Not even a second should be lost in doing this, for you know that it takes only a very short time for the blood in the limb to reach the heart. After the ligatures have been tied, a few cuts should be made in the wound, so as to allow it to bleed freely in order that at least a portion of the poison may escape along with the blood. (The blood from the wound may be sucked up, but this should be done with great care for, should the person who sucks up the blood happens to have any wound in his mouth or lips, the poison would immediately get into his blood. The sucked blood should be spat out and the mouth well gargled with water). After some blood has been allowed to escape, potassium permanganate should be well rubbed into the wound. This substance has the property of neutralising the poison to a certain extent. Burning the wound with a red hot iron is also good as burning will destroy the poison. A medical man or an expert in the treatment of snake bite should be always consulted.

Stings of bees and scorpions and bites of centipedes are also of frequent occurrence. When the bees in a hive are

annoyed, they attack us and leave the poisonous sting in our flesh. This is attended with intense pain and swelling. The sting left in the flesh must be looked for and removed, and the wound touched with a little tincture of iodine.

The scorpion has a rounded sting at the end of the tail, drawn out into a fine sharp needle. Inside the sting is the poison bag which opens to the outside at the end of the sting by a minute duct. The scorpion punctures the skin with the needle point of the sting and injects a minute drop of poison into the flesh. This is attended with extreme pain and swelling. The centipede has a pair of sharp poison jaws (claws) at the anterior end of the body behind the mouth, by means of which it bites. In both these cases application of ammonia acetic acid and water, or garlic will soothe the pain.

Bites of rabid dogs are dangerous. A rabid dog can be easily recognised by its behaviour. It runs about aimlessly and bites any one who attempts to stop it. The person bitten should consult a doctor and if found necessary proceed at once to a Pasteur Institute where such cases are treated by specialists.

Identification of Poisonus Snakes.—To recognise poisonous snakes and to distinguish them from non-poisonous ones require experience. The common poisonous snakes of South India are the cobra, the vipers and krait. *The cobra* is easily recognised by the characteristic spectacle mark on the back of the expanded hood. The mark consists of two round black patches joined together by a V-shaped line. *The Russel's viper* has a flat head covered with small scales and a stout buff coloured body with three longitudinal rows of large oval spots on the back. Besides the Russel's viper there are one or two other vipers which are common in our Presidency. In all vipers the top of the head is covered with numerous small scales unlike other snakes in which the headscales are large and symmetrically

arranged. *The krait* has a shining black body with a series of white bands across the back. The bands are in pairs and are more evident posteriorly.

Fainting.—Fainting may be due to several causes such as extreme physical fatigue, sudden fright, great heat, etc. The heart beat gets weak, and the blood supply to the brain becomes insufficient. As the brain will not work without sufficient fresh blood the person becomes unconscious.

In a case of fainting the person should be laid on his back with the head slightly lower than the body, as this will help the flow of blood into the brain. His clothes must be loosened and those at the neck removed. Cold water should then be dashed in the face. The cold water will stimulate the nerves and this will make the heart beat stronger. Smelling salts may be applied to the nostrils. People should not crowd round the patient who should be allowed plenty of fresh air. When he has almost recovered, a slight stimulant such as a cup of tea or coffee may be given him.

Cuts and Wounds.—Cuts and wounds are common accidents. If the cut is small, the bleeding will mostly stop of itself, due to the wonderful property of the blood to form a clot at the wound, and prevent an escape of it. If the bleeding does not stop, the wound must be washed with cold water, since cold will contract the blood-vessels and lessen bleeding. Then apply a little tincture of iodine or boric acid to the wound and dress it with a clean rag. If the cut is caused by a glass piece, thorn, etc., the wound must be thoroughly washed in clean water and the foreign body must be carefully searched for and removed before dressing the wound. The application of cowdung, mud, etc., to wounds is dangerous, since there is a chance of poisonous germs present in these substances being introduced into the blood.

In the case of deep cuts the bleeding should be promptly stopped as, otherwise, the loss of blood may become so great that the person may even collapse. If the blood-vessel that is cut in an artery the blood comes out in jerks or spurts, a jerk for every beat of the heart. In the case of a cut vein the flow of blood from the wound is steady and continuous. In either case bleeding is stopped by applying pressure on the blood vessel that is concerned. In the case of a cut artery pressure must be applied to the main artery *above* the wound and in the case of a cut vein *below* the wound.

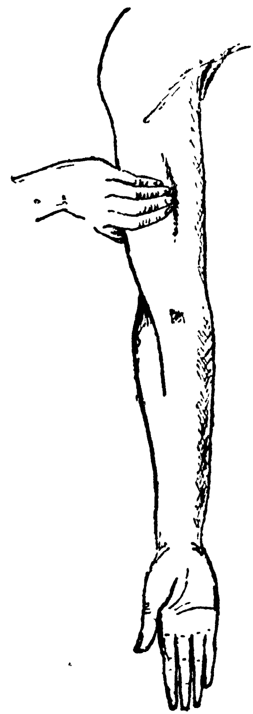


Fig. 51. **Applying pressure on brachial artery.**

In the case of a cut artery, pressure must be applied to the main artery above the wound—that is, between the injured part and the heart, so that blood may be prevented from reaching the cut. For example, if the cut is on the fore-arm, pressure must be applied to the brachial artery lying on the side of the upper-arm on the inner edge of the biceps muscle. You must practise finding out for yourself the position of the main arteries in the body. There is one in the upper-arm, two in the fore-arm, one in the thigh, two in the leg and one on each side of the neck. By pressing tightly with your fingers the brachial artery in the upper arm, you will see how soon the bleeding from the cut artery in

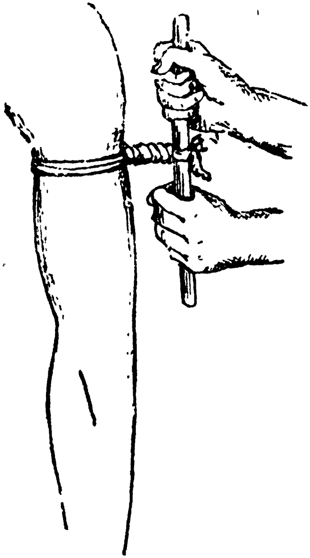


Fig. 52. **Tourniquet.**

the forearm decreases and stops. Bleeding is very soon arrested by tying what is called a tourniquet round the limb *above* the wound. It is done in the following way. Tie a piece of strong cloth round the limb with a coin or a smooth round pebble pressed against the artery. Passin a stick through the knot and turn it round to tighten it. The artery will thus be sufficiently pressed and the bleeding will stop. After keeping the tourniquet for about fifteen minutes, loosen it and see if the bleeding has stopped completely. If not, tighten it again and keep it for another fifteen minutes, loosen it again for a while and repeat the process till the doctor arrives. In the case of bleeding from a cut vein, the tourniquet should be applied below the wound.

Fractures.—When a bone gets broken, it is said to be fractured. It is the long bones of the limbs that usually get fractured. Fractures are of two kinds,—simple and compound. In a *Simple fracture* the bone only is broken and the skin is in tact. When a bone gets broken and the rough broken ends of the bone tear through the muscles and project through the skin, the fracture is said to be *compound.*

All cases of fractures must be handled by a doctor. But before the doctor comes or before the patient is taken to the doctor, there are certain things to be promptly done. These can be done by any intelligent person possessing a knowledge of first aid.

When a fracture occurs, great pain and swelling result, and there is a noticeable alteration in the shape of the limb. The first thing to be done is to straighten the broken limb by pulling it outwards with some force. This will bring the broken ends together. The limb should be kept in this condition and should not be allowed to move. For this purpose two or more splints (long flat pieces of wood or bamboo) are applied to the limb, one on each side and tied to it with bandages, one above the point of fracture and the other below it. (You must remember that, in order to render first aid when accidents happen, you have to be very resourceful, for it is not always that you will get ready made and the best things for use. For example, when your class-fellow breaks one of his bones on the play ground, it may be difficult for you to get ready-made splints. You must not wait but should make use of whatever suitable is available at hand—an umbrella, a walking stick or a scout's staff. For tying bandages you may have to tear pieces off your own cloth or shirt). The patient thus bandaged should then be carried in a stretcher.

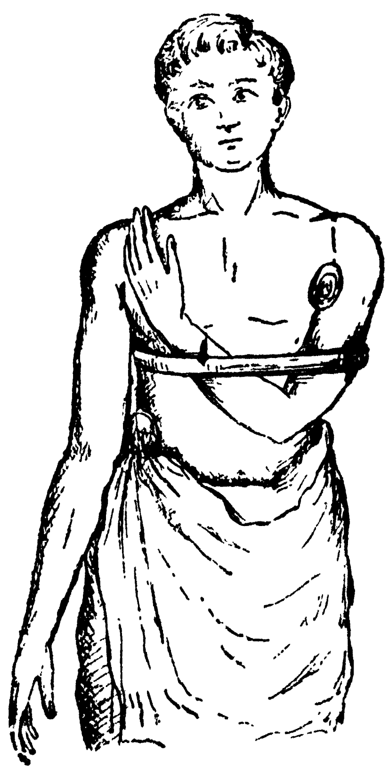


Fig. 58. Fracture of collar bone.

The collar bone may sometimes get fractured when a man jumps or falls down from a height. The first aid to be rendered in this case is a little different. You know that the collar bones are attached by their inner ends to the breast bone and by their outer ends to the shoulder blades, and that their function is to keep the arms well apart in order to give them a wide range of movement. If we had no collar bones, our arms would fall forwards. This is exactly what happens when a collar bone gets broken. The arm of the side in question falls forwards and downwards. By keeping the arm upwards and backwards, the broken ends of the bone can brought together. For this purpose a large pad of rolled up cloth should be placed under the arm-pit. The arm should then be kept immovable by placing the hand on the opposite shoulder and bandaging the whole arm securely to the body round the chest. (See fig. 53).

Compound fractures are much more serious than simple fractures. When the fractured limb is pulled outwards, the protruding ends of the broken bone will pass inside and the two broken ends will come together. The wounds on the skin should be cleaned and splints should be applied as in the case of simple fractures.

Dislocation.—When the round end of a long bone, *e.g.*, the humerus, gets out of its socket, the bone is said to be dislocated. All cases of dislocation must be attended to by a doctor.

Sprains.—When a joint, such as the ankle, gets suddenly twisted, the ligaments which unite the ends of the bones forming the joint get twisted and wrenched. The result is a sprain. Sprains are accompained by pain and swelling. Hot water should be continuously poured on the joint for some time by means of a vessel with a spout, and the joint should be given complete rest for a few days.

Drowning and artificial respiration.—You may have heard of instances of boyscouts having rescued persons

from drowning. When other people would merely have looked on, not knowing what to do, the boyscouts did the right thing at the right time and saved their lives. When a person who has been under water for some time is taken out, it will be found that he has ceased to breathe. His diaphragm does not rise and fall, and the muscles which pull the ribs up do not work. He is unconscious and he looks apparently dead. Prompt action is necessary to bring him to life. Remove all tight clothing from his body, especially from the neck and chest. Clean his mouth, nose and throat, for these may contain dirt or weed or some other foreign matter. Rub the back and front of the chest and apply snuff or smelling salts to the nostrils. If the patient does not still begin to breathe, artificial respiration should be immediately started.

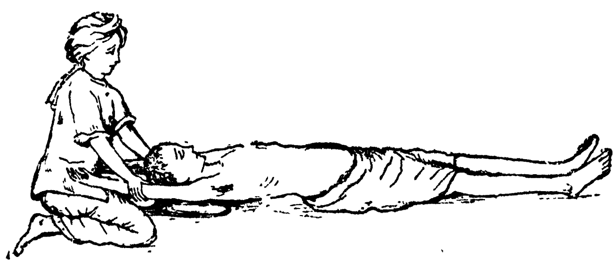


Fig. 54. **Sylvester's method**—Inspiration.

Artificial respiration is a method of letting air into and driving it out of the lungs by expanding and contracting the chest by artificial means, and thus induce the muscles concerned and the diaphragm to work of their own accord. There are two methods of carrying out artificial respiration. One of these is known as Sylvester's method and is as described below.

Lay the person on his back and support his head and shoulders on a cushion. Draw forth the person's tongue lest it might block the throat and prevent the free passage of air

Fig. 55. **Sylvester's method**—Expiration.

into and from the lungs. Let some one hold the tongue with a piece of cloth. Kneel behind the person's head and grasp his arms above the elbows (See fig. 55) and slowly raise them upwards. By this means you artificially expand his chest by raising his ribs and so allow air to get into his lungs. After holding the arms up for a second or two, bring them back and press them down firmly and gently against the sides of the chest. In this way you compress the chest and make the foul air escape from the lungs. Continue these movements at the rate of 16 times a minute until the patient

Fig. 56. **Schafer's method**—Expiration.

begins to breathe of his own accord. When natural breathing returns, the artificial respiration must be stopped and the person's skin should be well rubbed to promote warmth and circulation.

The other method which is considered to be better is known as Schafer's method. It is done in the following way.

Place the person face downwards on the ground with the head turned sideways and resting on his forearm (See fig. 56.). Place a folded-up cloth or a small cushion under the lower part of his chest. Kneel across him and

Fig. 57. Schafer's method—Inspiration.

leaning forwards, place both your hands on the lower part of his back, one hand on each side. Press on his chest gently but firmly so that the air and any water present in them may be forced out of the lungs. Now lean backward and remove the hands from the patient's back. Fig. 57). The release of pressure will allow the chest to draw air into the lungs. This alternate application and withdrawal of pressure must be repeated about 16 times per minute until natural breathing is restored.

Artificial respiration may be employed not only in cases of drowning, but also in cases of attempted hanging, suffocation, etc.

CHAPTER XIII

BACTERIA AND DISEASE GERMS

In our tanks and wells, in the soil, and in the very air we breathe, there are numerous kinds of very minute creatures, so minute that they are visible only under the high powers of the microscope. Most of these are plants and are called *bacteria.* Though they are present almost everywhere, only very little was known about them till recently. The microscope has now made it possible for us to know something about these wonderful creatures. Bacteria have all sorts of queer shapes. Some are spherical and look like minute dots; some are rod-shaped; others are spiral, and so on. Like all other organisms bacteria grow and multiply. The bacterium multiples in a currious way by simply dividing itself into two. Besides bacteria there are several other low organisms that multiply in this way. Since it requires only a few minutes for a bactrium to grow to its full size and produce offspring, a single bacterium can, in a few hours, give rise to millions of offspring.

A high temperature like that of boiling water kills bacteria. That is why boiled water is said to be better for drinking than water freshly drawn from wells. Boiling kills all poisonous germs in the water. During an outbreak of cholera you are advised to eat only well-cooked food, for cooking kills all the disease germs in the food. A doctor keeps the lint or linen in boiling water for a few minutes before applying it to the wound in order that it may be absolutely free from germs. Just as bacteria are killed by great heat, so they do not also thrive in great cold. You know that milk, if kept long, turns sour. The sourness is caused by a kind of bacteria getting into it, multiplying rapidly and producing an acid. In certain parts of India where it is intensely cold during winter months, milk can

be safely kept overnight for, as I have just told you, bacteria do not thrive in great cold.

During unfavourable times some kinds of bacteria form spores. Spores are little ovoid bodies with hard coat. The spores can withstand much heating and are not easily killed. When conditions become favourable, the spores germinate and become active bacteria.

Not all kinds of bacteria are harmful. Many are beneficial, as for instance, the putrefactive bacteria. Every day thousands of animals and plants die. As soon as an animal or a plant dies putrefaction begins. The putrefaction is due to bacteria, millions of which begin to attack the dead animal or plant and use it as food. They destroy the dead matter breaking it down into simpler substances which are returned to the soil and air fit to be used as plant food. Had it not been for the work of these bacteria, the earth would soon be full of dead bodies and would no longer be a place worth living in. Again, if all the useful substances in the dead plants and animals are not made available as food to living plants and animals, life would soon cease. The putrefactive bacteria are thus of immense service to man.

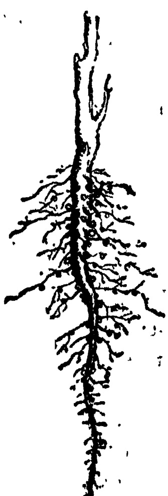


Fig. 58.—Root of pea showing nodules.

If you have ever pulled up a bean, pea or any other plant belonging to the Natural order Leguminosae, you will have noticed a number of small swellings or nodules on its roots. These nodules are full of a certain kind of bacteria. Several millions of bacteria may be found in the roots of a single plant. These bacteria take up free nitrogen from the air circulating in the soil and make it suitable for the use of the plant.

There are bacteria in the human body which are practically harmless. In the large intestine there are bacteria which, unless they are present in enormous numbers, do not produce any disease.

Some kinds of bacteria cause disease. Measles, small-pox, cholera, typhoid fever, plague, diphtheria are some of the common diseases produced by bacteria. Malarial fever and dysentery are caused not by bacteria but by minute animalcules. Both the bacteria and animalcules that cause disease may be termed disease germs. Let us try to know something about some of these disease germs, how they are carried from man to man, and what preventive measures may be taken against them.

Cholera.—Cholera is a dreadful disease and often becomes an epidemic. It is caused by a kind of bacteria which, on finding its way into the intestine, multiplies at an enormous rate and produces a powerful poison (toxin). This poison causes purging, fever, and vomitting. Purgings become very frequent till at last they become colourless and watery. More than fifty per cent of the people attacked, succumb. The disease is largely spread by water. Drinking water in wells and tanks gets easily contaminated in various ways unless particular precautions are taken. The germs of this disease are also carried by flies. Flies settle on the patients' purgings and carrying germs on their feet settle on sweets, fruits, milk, etc. A single fly is capable of carrying nearly 6,000,000 germs on its body.

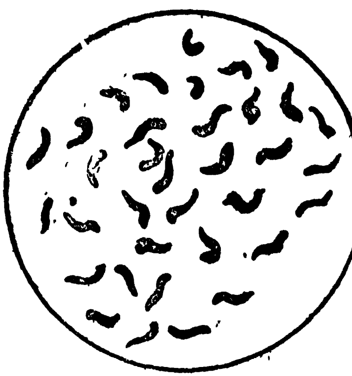


Fig. 59.—**Cholera germs.**

Typhoid fever.—Typhoid fever is caused by another kind of bacteria, which enters the alimentary canal and causes inflammation and ulceration of certain parts of the intestines. The germs are carried either through drinking water or by flies as in the case of cholera. People who have recovered from an attack of typhoid may retain the germs in their body for a long time, though they may not have any harmful effect on them. Such people are also a source of infection and are called 'carriers'. Some years ago, there was an Irish cook, by name Mary, in New York, who was a chronic carrier of typhoid and who was, therefore, called 'typhoid Mary'. For several years, in every family that had engaged her, there had been typhoid cases, though she herself was quite healthy.

Consumption.—Consumption is another disease caused by bacteria. The germs of this disease are carried through the air. When the germs get into our lungs they produce consumption. Large numbers of these bacteria are given off by consumptives in their sputa. When the sputa dry up, the bacteria escape from them and float in the air. Flies have also been known to carry the disease. You know that flies are attracted, by sputa. They feed on them and excrete the bacteria. Using drinking vessels, spoons, etc., used by consumptives is another mode of infection.

Plague.—Plague which carries off thousands of human lives every year is another bacterial disease. In India, during the great outbreak which lasted for three years, from 1901, 2,000,000 died of this disease. The disease occurs chiefly among rats. The rats become infected with the bacilli and die. When the rats die, the fleas on their bodies which have become infected communicate the disease to man.

Insects and disease.—Insects play a prominent part in the transmission of disease. Among the most important of these disease carriers are the house fly, the mosquito, the rat flea, and the bed-bug.

The *house fly* has earned a notoriety for itself as a disease carrier. It is a carrier of typhoid, cholera, dysentery, diarrhoea, tuberculosis, and perhaps several other diseases also. Thousands of lives are lost every year due to diseases caused by infection carried by house flies. The flies cannot, therefore, be tolerated though they are of some service to us as scavengers. You know that flies have no scruples and that they swarm everywhere. You find them feeding on filth, excrement and sputum, and you find them swarming in public restaurants, coffee houses and sweetmeat shops. They swarm in unclean privies and are as fond of the nightsoil as of the milk or sugar on your table. Flies are a menace to public health and we have to get rid of them at any cost. *Cleanliness* is the chief preventive measure against flies. In large towns and cities, co-operation of the people is needed and any amount of money spent by municipalities and the Government to keep down this insect will never be too much. At the same time every one of us must do our little bit in the matter. We must keep our dwellings and premises absolutely clean. *Where absolute cleanliness prevails there will be no flies.*

The mosquito.—A kind of mosquito called *Anopheles* transmits malarial fever from man to man. Malarial fever is caused by a tiny animalcule which gets into our blood

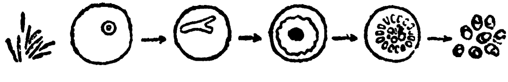


Fig. 60. Malaria germs.

1. Spores introduced into the blood by the mosquito
2. 3. 4. 5.—The parasite living within the corpuscle
6. Young ones set free by the rupture of the corpuscle

and attacks the red corpuscles. Each malarial germ enters a red corpuscle, grows within it feeding on the corpuscle, and gradually gives rise to a number of young ones. The corpuscle

bursts, setting free the young malarial germs together with a certain kind of poison that has been produced by them. Each of these young ones attacks a fresh corpuscle and in its turn produces a number of young ones and the poison mentioned above. When an anopheles mosquito bites a person suffering from malaria, it sucks up along with the blood a number of these germs. The germs undergo certain changes in the body of the mosquito and give rise to numerous minute spores which collect themselves in the salivary glands of the insect. When this mosquito bites a healthy individual, it introduces these spores into his blood. Each spore enters a red corpuscle and repeats the life cycle. Thus the anopheles mosquito plays a very important part in the transmission of this disease.

A mosquito of the 'culex' variety is responsible for the spread of the nasty disease called Elephantiasis or the Elephants' foot. The disease which is very common in some places in the Presidency is caused by a worm, a full grown specimen of which measures nearly four inches. The young ones are present in the blood and are about 1/75 of an inch long. The young ones are transmitted from man to man by the mosquito.

The only way to prevent diseases transmitted by mosquitoes is to keep these insects in check. This is not so difficult as it looks. But it requires the intelligent co-operation of officials, individuals and school children. You must find out all the breeding grounds of mosquitoes in your village, such as small puddles and pits of dirty water-ponds, tanks, etc. All such breeding grounds as could be removed should be done away with. Large tanks and ponds should be occasionally treated with kerosene. The sanitary officials know how to do it. The problem is more difficult in towns and cities, but municipal corporations and sanitary departments must do their best.

The Rat Flea.—As has already been stated, the rat flea transmits the germs of plague from rat to man The destruction of rats is one of the preventive measures that have been suggested. You have been told that rats get the disease first and die. Rat-falls give us the warning that plague is breaking out. As soon as a rat fall is noticed, the house should be immediately evacuated and thoroughly disinfected, and the plague-stricken fallen rat must be burnt.

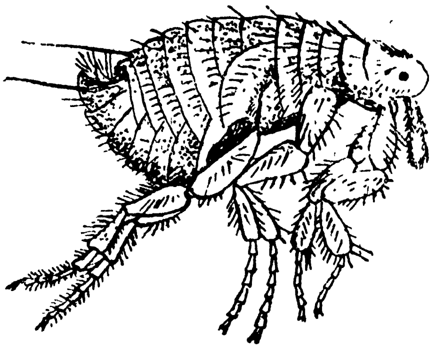


Fig. 61.—The Rat flea.

The Bed Bug.—The bed bug being a blood sucking insect is also capable of transmitting disease germs. It is necessary, therefore, to keep this insect out of our houses. When once it has got a foot-hold in our furniture or in the chinks in the walls, it is difficult to get it out. Scrupulous cleanliness and systematic destruction are the only two methods of keeping this insect under control. All furniture in the house should be frequently wiped with a cloth dipped in a solution of phenol or other disinfecting fluid

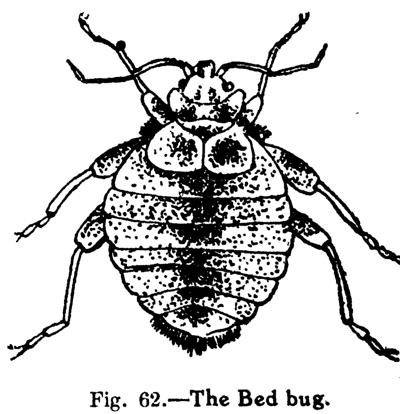


Fig. 62.—The Bed bug.

and the walls should be white-washed with lime at least twice a year.

Inoculation and Vaccination.—How do disease germs cause illness ? Disease germs on gaining entrance into the body multiply rapidly and produce poisons know as 'toxins.' It is these poisons that cause illness. Each kind of disease germ produces a distinct kind of toxin. We have seen that when foreign bodies, such as bacteria, get into our blood or tissues they are attacked and destroyed by the white corpuscles. The white cells of the blood do a lot of service in this way. But sometimes the invaders (disease germs) gain the upper hand and the white cells find it difficult to overcome them. The disease germs multiply and produce toxins. Even then our body continues to resist by producing counter poisons or 'antitoxins' which act upon the toxins and render them harmless. If antitoxins are produced in sufficient quantity, we recover from the desease. The antitoxins remain in the body and are often helpful in preventing a second attack of the same disease.

Antitoxins prepared from animals are made use of in the treatment of human beings. Toxins of a particular disease, for instance, diphtheria, are injected into the blood of an animal, say, the horse. The animal produces antitoxins. The toxin dose is gradually increased, with the result that antitoxins are produced with greater vigour until the animal is perfectly able to resist the disease. The animal is now said to be 'immune' to the disease. The serum of this horse is taken and injected (inoculated) into human beings. By inoculation of the serum we introduce into the blood the disired antitoxin, which may give the person protection against the particular disease or if he is already suffering from it, assist him in overcoming it. Inoculation is adopted as a preventive measure against a few bacterial diseases such as plague, typhoid, diphtheria, etc. In some cases, instead of serum, the dead bodies of the germs are inoculated. This is done in the case of cholera and it

has been found that healthy persons are protected from infection.

Vaccination is a successful method of prevention against small-pox. The substance introduced into the blood is called *Vaccine* and is obtained frow the cow. Cows suffer from a disease known a Cow-pox, similar in nature to small-pox but very much milder than it. Vaccine is the toxin of the Cow-pox disease. When this toxin is introduced into the blood, the body produces an antitoxin which remains in the body and gives protection against small-pox. Even if one who is vaccinated happens to get the disease, the attack will be very mild. Small-pox being very common in our country, it is essential that every child must be vaccinated.

Cleanliness.—You must keep yourselves fit. It is one of your primary duties. You cannot be of any use either to youselves or to your country if you are not fit and strong. Cleanliness is absolutely essential in order to keep oneself fit. There is much truth in the saying that "Cleanliness is next to godliness". Cleanliness is the most important preventive measure against diseases in general. *Where there is dirt there will be disease.*

You must wash yourselves everyday in clean water. The dirt from the skin should be removed by using soap. You know that the skin gives off sweat from the numerous sweat glands in it and an oily stuff from the oil glands. The oily matter and sweat blocking up the numerous sweat pores are best removed by soap. The sweat pores should always be open so that the sweat may easily eascape from the body. While bathing the body should be well rubbed with the hand so as to stimulate the blood vessels under the skin to greater activity. The parts of the body usually kept exposed *viz.*, the hands, feet and face must be frequently washed. The hands should be cleaned and the mouth should be well gargled with cold water before you sit for your meal. Some boys do not pay attention to their finger nails. They allow them to grow with the result that dirt accumu-

plates beneath them. The nails should be kept cut short and thoroughly clean. Biting the nails is a very bad habit.

Several diseases of the body are now traced by medical men to bad teeth. Special attention must be paid to these sutructures. You have already been told in a previous chapter about the proper way to cleanyour teeth. It is a good practice to gargle the mouth several times after a meal, since continued rinsing of the mouth with water removes all the food particles from the gaps between the teeth.

Too much clothing is bad in a hot climate like that of our country because it will hinder the evaporation of sweat from the body. The clothing that you wear must be such as will allow air to pass through freely. Khaddar is very good in this respect. You will feel very comfortable in a clean dhoti and a clean white loose khaddar shirt. The same clothing should not be worn for more than a day without being washed. Bed sheets and pillow covers should be frequently renewed and bedding and pillows should be exposed to the sun for few hours at least once in a fortnight.

The yard and premises of your houses should be kept absolutely clean. Rubbish should not be thrown anywhere about the compound, but should be deposited in a bin kept for the purpose, the contents of which should be removed once in a week or oftener. No decaying animal or vegetable matter should be present anywhere in the compound. All likely breeding grounds of mosquitoes should be done away with.

The privy must receive particular attention. The earth closet in vogue in many villages is a danger to public health. The privy should be built according to sanitary laws and shauld be kept clean. The night soil should be daily removed and the receptacles should be washed with phenol solution. It would be desirable to keep a quantity of the solution in the receptacles as it will kill fly larvae, hookworm eggs, etc. The floor and the walls of the privy should be frequently washed with a disinfectant.

SYLLABUS IN PHYSIOLOGY, HYGIENE AND FIRST AID

(1) The general build of the human body; the chief viscera and their arrangement.

(2) The human skeleton; bones and classes of joints.

(3) The muscular system; movement; postures and mal-postures in sitting, standing, and walking; physical fatigue; general effects of physical exercise.

(4) The circulatory system; the blood and its nature; the heart and blood vessels; the heart beat; the pulse; the course of circulation; the functions of blood.

(5) The respiratory system; the lungs and air passages; respiratory movements; changes in the air, in the lungs and blood during respiration; supply of oxygen and removal of carbon-dioxide from the tissues; the uses of oxygen in the body; the work of the body; energy in the food set free by oxidation; correct breathing and breathing exercises; advantages of an open air life; diseases caused by breathing impure air; ventilation.

(6) The digestive system; the alimentary canal and its parts; the glands connected with the alimentary canal and their secretion; food-stuffs and their classification; the process of digestion and absorption; composition and value of food-stuffs; mixed diet; teeth and their care; causes of headache and fever; constipation and how to prevent it.

(7) Excretory system: excretory organs, lungs, skin and the kidneys; work of the kidneys; skin and its functions; cleanliness; bathing and kinds of bath; skin diseases, their causes and prevention; regulation of body temperature.

(8) The nervous system: brain, spinal cord and nerves; parts of the brain, cerebrum, cerebellum, medulla oblongata

and their functions; functions of the spinal cord; reflex action; physical and mental fatigue.

(9) Sense organs: sight, care of the eye, use of glasses; the ear and its functions, causes of defective hearing; sense of taste and smell.

(10) Bacteria and disease germs: beneficial, harmful, and harmless bacteria; bacteria in the human body; insects and diseases; preventive measures; destruction of germs; value of inoculation and vaccination.

(11) First Aid: treatment of burns, scalds, bites, stings and poisons; identification of poisonous snakes, treatment of cuts and wounds; fainting, its causes and treatment; fracture and bandaging; drowning, artificial respiration.

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